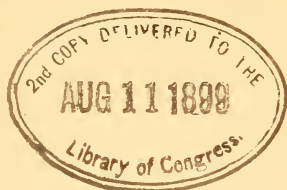


AN
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AND
HYGIENE

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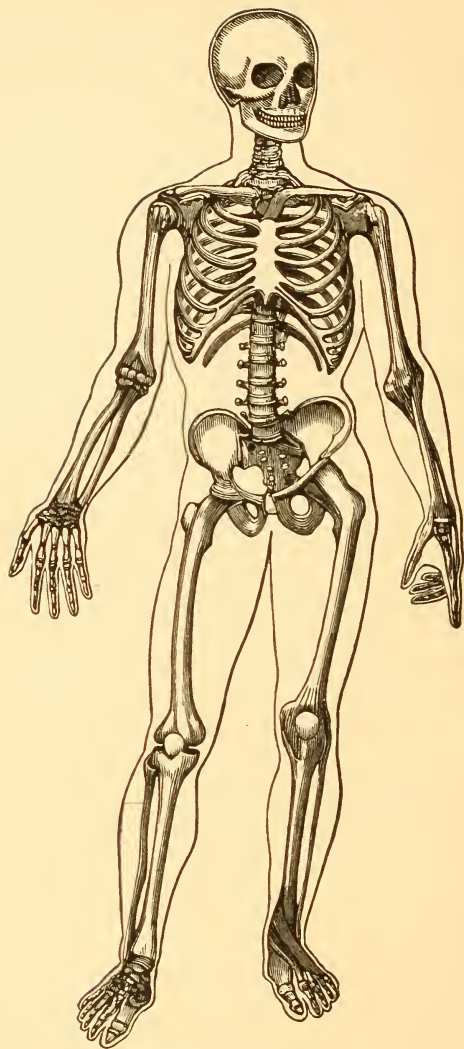
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SKELETON.

THE OUTER LINES SHOW THE FORM OF THE HUMAN BODY WHEN THE
SKELETON IS CLOTHED WITH FLESH.

AN
ACADEMIC PHYSIOLOGY
AND
HYGIENE.

EMBRACING SPECIAL CHAPTERS ON FOODS AND THEIR PREPARATION; WATER AND OTHER BEVERAGES; AIR AND VENTILATION; THE REMOVAL OF WASTE MATTERS; EXERCISE, REST, AND RECREATION; BATHING AND CLOTHING; HYGIENE OF THE SPECIAL SENSES, AND THE EFFECTS OF STIMULANTS AND NARCOTICS ON THE HUMAN SYSTEM.

BY

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AND "GOOD HEALTH FOR CHILDREN."

AND

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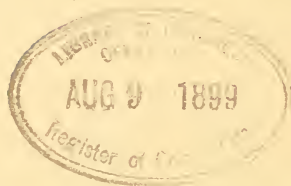
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PREFACE.

IN the preparation of this volume an endeavor has been made to keep steadily in view the fact that the study of the structure and functions of the body and of its various organs should conduce to an intelligent conception of the normal conditions and processes through which health and life are maintained. Anatomy and Physiology, while not being unnecessarily neglected, have been treated as a means rather than as an end.

In early eras of thought, bodily disorder and disease were regarded as the gifts of the gods, and as marking their judgments ; and the task of preventing plagues, fevers, and the mysterious diseases of brain and mind, was esteemed as hopeless and impracticable. But in course of time the lessons taught by bitter experience and the progress of modern civilization began to exercise a distinct influence upon public health. The knowledge possessed by the few was sought by the many ; and the domains of the theologian and the scientist began to be invaded in the search for light on all subjects pertaining to moral, mental, and physical well-being. The sources and causes of disease began to be tolerably well understood, and it became known that man possesses the power of preventing many of the ailments which shorten life and decimate the population of communities and nations.

Hygiene founds its lessons to the individual upon the same basis as those which it inculcates on the masses. There are so many conditions over which an individual has control, that it is impossible to determine which is absolutely of the greatest importance. It may be safely said that one must first possess the intelligent conception of the normal conditions of structures and processes to which we have referred, and then must become acquainted with the nature, quantity, and proper preparation of foods, and the conditions essential to their healthy digestion; the composition of the beverages which he imbibes, their values, and their effects on the organism; the composition of air, the causes affecting its purity, and the means of securing its change and renewal when vitiated; the relations of proper bathing, cleanliness, and clothing to health must be understood; the part played by exercise, rest, and recreation in maintaining physical and mental vigor must be known; the dangers attending the accumulation of refuse matters in the vicinity of human habitations must be appreciated, and the means of effectively disposing of them should be known; and finally, the individual should acquire knowledge that will enable him to render intelligent assistance, and often save life, in emergencies. The development of public interest in all matters relating to sanitary science renders needless an apology for adding special chapters on the foregoing topics.

While the treatment of each topic is elementary, and divested of technicality as far as practicable, the essential facts are stated with the fulness needed to set forth clearly their educational value. The authors have brought to bear special knowledge of the subjects on which they have written, together with practical experience in teach-

ing them. In addition, the standard works of Dalton, Carpenter, Huxley, the manuals of health-science of Wilson, the American Health Manuals, etc., and the writings of many other eminent scientists, have been consulted, and most valuable assistance derived from their teachings.

In conclusion, the authors trust that this volume will possess attractions, and attain a popularity and usefulness, equal to those of the other works of the series which it is intended to complete and crown.

O. M. B.

H. C. V. G.

FEBRUARY, 1893.

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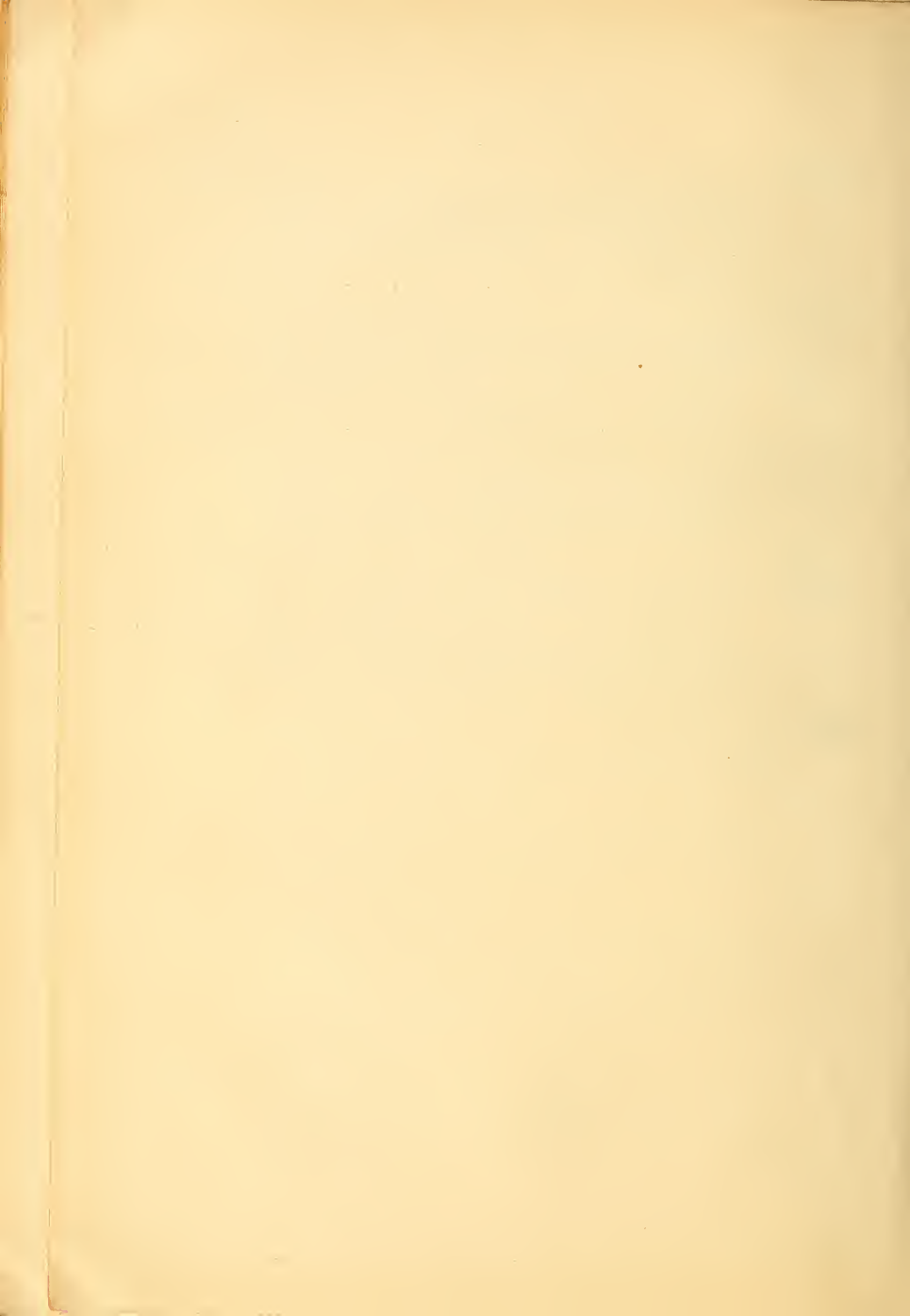
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ACADEMIC PHYSIOLOGY.

CHAPTER I.

INTRODUCTORY.

1. **Knowledge of the Body.** — The investigations and experiments made by some of the most profound thinkers of all countries and ages have been employed in the discovery of the structure and functions of the human body. This continued study and research has not been inspired by mere idle curiosity and for its gratification. The preservation of health, and the desire for long life, as a sequence, have stimulated inquiry into all that continued to remain unknown of the structure of the body, of the offices and actions of its various organs, of the relations of each organ and set of organs to all others, and of the conditions necessary to the healthy and harmonious activity of the whole organism.

2. Having a knowledge of only the general outlines of the structure of the body and of its various functions, all can understand important hygienic laws, the proper observance of which tends to insure health, long life, and happiness. It is of but little use to know how our bodies are constructed and what functions are performed by their

organs, unless we utilize such knowledge in the prevention of disease and the preservation of life. When we know just what results will follow the violation of each law of existence, we become measurably the arbiters of our own health; and our enlightened judgment stands as a guard over our lives, possibly preventing the first step toward disease.

3. **Divisions of the Subject of Study.** — The sciences which treat of the structure, functions, and preservation of health of the body, are *Anatomy*, *Physiology*, and *Hygiene*.

4. *Anatomy* (Gr. *ana*, up; and *temnein*, to cut) is the science which describes the structure, situation, and relation of the different parts of the body. A knowledge of this comes only from a minute examination of all the parts that constitute the structure, and has been obtained through microscopic examinations and by dissections of lifeless bodies.

5. Through continued investigation and experiment the amount of knowledge has been enormously increased, and that which was already possessed has been rendered much more accurate. Surgical skill has kept pace with this progress in many directions previously unthought of. Operations that were formerly regarded as quite certainly fatal to life, are now relieved, to a great extent, of their dangers and terrors. The steady, onward progress of scientific knowledge enables the surgeon to relieve diseased conditions by means of operations that would, in former times, have been ascribed to the agency of the "black art."

6. *Physiology* (Gr. *phusis*, nature, and *logos*, discourse) is the science which describes the functions of organs and sets of organs, or the mode in which they operate. Physiological knowledge comes, in part, from experiment

and the study of structures, and largely from experience and observation. Experiments made upon the lower animals have added greatly to our knowledge of physiological processes.

7. According as it treats of one or other of the two great groups of organic beings, it is either *animal physiology*, or *vegetable physiology*. *Human physiology* is, of course, restricted to the human body.

8. **Hygiene** (Gr. *hygeia*, health) is the science, practical hygiene the art, of preserving health. While it is the province of medical science to treat disease when it actually appears, it is that of hygiene to enable us so to place ourselves in relation to our surroundings, and so to regulate our lives, that disease may be warded off. Medicine deals with cure, hygiene with prevention ; and prevention is better than cure.

9. The science of health preservation is wide in its scope, embracing as it does inquiries into nearly all other sciences. It calls upon chemistry to contribute information concerning the composition of foods, the nature of the impurities of air, and the contaminations of water-supply. It appeals to physics to explain the diffusion of gases, — how noxious gases from sewers gain access to our dwellings, and calls upon it for contrivances to abate the evil ; again it calls upon this science to explain methods of securing proper ventilation of our abodes. It demands of botany and zoölogy descriptions of the minute parasites that sometimes infest foods and render them unwholesome. Of geology it inquires the nature of the strata from which supplies of water are obtained ; and from physiology it learns the conditions which should prevail in healthy action of the body.

10. Composition of the Body. — There are sixty-four substances which are known as simple substances, or *elements*; and they are so regarded because they cannot be decomposed and resolved into simpler constituents. All animal, vegetable, and mineral bodies are formed by a union of various numbers of these elementary substances in different proportions and ways.

11. Chemistry has demonstrated that the human body contains fourteen elementary substances, viz., oxygen, hydrogen, nitrogen, carbon, phosphorus, calcium, fluorine, sulphur, chlorine, sodium, iron, potassium, magnesium, and silicon. In the bodily structures these elements do not exist in simple form, but are so combined as to form chemical compounds called *proximate principles*.

12. The proximate principles, or compound substances constituting the body, are of three classes, viz., those derived from the *mineral* or inorganic world, as water, chloride of lime, phosphate of lime, phosphate of soda, chloride of sodium (common salt), and other salts; the *carbonaceous* compounds, as starches, sugars, and oils; and the *nitrogenous* compounds, as albumen, fibrine, etc. These exist in a healthy human body weighing 154 pounds in about the following proportions: *Water*, a compound of oxygen and hydrogen, 111 lbs.; *gelatine*, composed of carbon, hydrogen, oxygen, and sulphur, 15 lbs.; *fat*, 12 lbs.; *phosphate of lime*, forming the principal part of the earthy matter of the bones, 5 lbs. 13 oz.; *carbonate of lime*, also entering into the composition of bone, 1 lb.; *albumen*, found in the blood, brain, and almost all the other organs, 4 lbs. 3 oz.; *fibrine*, forming the clot of the blood, and found in the muscles, about $4\frac{1}{4}$ lbs.; *calcium* found in the bones, 3 oz.; *phosphate of soda*, found in the brain and all

other nervous tissue, 400 grs. ; *phosphate of potash*, also found in the brain and nerves, 100 grs. ; *phosphate of magnesia*, found in the bones, 75 grs. ; *chloride of sodium*, 376 grs. ; *sulphate of soda*, found in the blood, more than 1 oz. ; *carbonate of soda*, in the blood and bones, about 1 oz. ; *sulphate of potash*, about 1 oz. ; *peroxide of iron*, in the blood and elsewhere, more than 9 oz. ; and *silica*, a very small quantity.

13. These substances and their proportions are not given here as necessary for memorization, but in order that the diversified nature of the composition of the body may be impressed. They are constantly undergoing change, being transformed into waste or effete products, which are discharged from the body. This change is necessary to life ; and in order to compensate for the waste occasioned by this constant destruction, new material must be regularly supplied. All the elements necessary for the maintenance of the composition of the body are derived from proper food, and are held in solution in the blood which distributes them to the various structures.

14. Food is taken into the body in obedience to a want made known by the sensation of *hunger* when it relates to solid or semi-solid matters, and by *thirst* when the want relates to water.

15. **Cell Structure.** — The microscope shows that animal as well as vegetable structures are composed of *cells* (Lat. *cella*, a store-room). A cell is a minute, membranous sac enclosing a more or less fluid mass of matter. In this substance, in most cells, are found one or more spots or nodules of condensed matter called *nuclei* (Lat. *nucleus*, a nut or kernel). These nuclei first exist in a transparent, structureless mass called *protoplasm*.

In the course of development, this matter breaks up into microscopic globules, each enclosing a nucleus ; and thus the cells are formed and multiply.

16. The Tissues of the Body. — The word *tissue* means, literally, a *woven structure*. Various modified in form and nature, the interwoven, grouped, or united cells form different tissues or solid portions of the body.

17. The *tissues* have been classified and named as follows : *Epithelial* tissue includes the skin and delicate lining membranes of the cavities of the body, the hair, and the nails of the fingers and toes ; *muscular* tissue, the contractile tissue of which all the muscles are examples ; *adipose* tissue, composed of fat cells and enclosed fat ; *cartilaginous* tissue, commonly called “gristle,” forms the surfaces of joints and the elastic frames of soft parts, such as the outer ear, the nose, etc., and constitutes the tendons of muscles ; *nervous* tissue constitutes the substance of the brain and nerves ; *connective* tissue is the delicate, membranous sheet which invests muscles and all the organs of the body, holding them in place, and separating parts from adjacent ones. Its chief use is that of support. *Osseous* tissue comprises the bones and the teeth.

18. The Fluids of the Body. — The *blood* is the most abundant fluid of the body, being estimated at about one-eighth of its weight. Beside the blood there are the fluids enclosed in the eyeballs, the tears, the saliva, the bile, the intestinal juices, the synovial fluid of the joints, etc., all of which will be more particularly noticed later.

19. Organs and Systems. — Any definite part of the body that has a special office or function to perform is called an *organ* (Lat. *organum*). Thus the *heart* is the principal organ for the propulsion of the blood ; the *lungs* the prin-

ciple organs of the breath ; and still more familiar, the *eyes* are the organs of sight, and the *ears* of hearing.

20. A number of intimately related organs engaged in the performance of the same general function constitute a *system*. Each set of organs is so arranged as to perform special offices of its own while acting in harmony with all others. Thus we have the *osseous* system, consisting of the bones, which gives support, protection to others, and supplies levers for the muscles ; the *muscular* system, composed of the muscles, supplies the means of motion to the body as a whole, and to each of its various organs ; the *digestive* system, comprising several organs, converts food into material for the nutrition of the whole body ; the *circulatory* system, composed of the heart, arteries, veins, etc., is employed in circulating the blood, thereby carrying nutrition to the various parts of the body ; the *respiratory* system comprising the lungs, air-passages, and certain muscles, etc., is employed in supplying oxygen and purifying the blood ; the *nervous* system, consisting of the brain and nerves, presides over all motion and sensation ; the *organs of excretion*, such as the kidneys, sweat-glands of the skin, etc., remove the effete material that can no longer be used in the body. In addition to these systems of organs, we have the separate organs of the special senses, the eye, ear, nose, tongue, and skin, by means of which we enjoy relations with objects in the world about us.

21. **Public Hygiene ; Personal Hygiene.** — Hygiene takes cognizance of every cause and condition which contributes to the maintenance of health and the prevention of disease. Owing to the absolute necessities where mankind is congregated in large numbers, as in towns and cities, every civilized nation or community enacts laws which deal with

questions of health and the prevention of the spread of disease. Sanitary regulations prescribe the conditions of abodes and their surroundings, as the carelessness or ignorance of an individual is liable at any moment to endanger the safety of his fellows. The removal of noxious refuse matter, the preservation of the purity of air and water supply, the wholesomeness of articles of food offered for sale, etc., receive more or less attention through legislative enactment. The isolation of persons sick with dangerous contagious disease, and the disinfection of clothing, utensils, and apartments to destroy the germs of disease, receive the supervision of public authority. By such means are prevented many of the ailments which shorten life and decimate the population.

22. But the intelligent *culture of health by the individual* far exceeds in power and effectiveness the mandates of nations, states, and cities in regard to health. It is through the acquisition of health-knowledge and the observance of *personal hygiene* by individuals that good health and prolonged life are to be attained. Disease and suffering are largely the results of ignorance. The lessons taught by the science of health to the individual are essentially those which form the basis of the compulsory health enactments of civil government. Every individual should become acquainted with the nature of foods, and the quantity necessary under varying circumstances; the proper preparation of food, and the conditions required for its complete digestion. He should understand the properties and effects of the beverages which he imbibes. The composition of air, the sources of its impurities, its effects when impure, the means for the expulsion of effete air and its replacement by that which is pure, should be

known. The relations of exercise, rest, sleep, cleanliness, and clothing to health should be understood. The hygiene of sight, hearing, etc., should be familiar knowledge. Finally, every individual should acquire knowledge which will enable him to render aid in emergencies and in the absence of the physician or surgeon.

"Nature does require
Her time of preservation, which, perforce,
I, her frail son, amongst my brethren mortal
Must give my attention to."

SHAKESPEARE.

Points Suggesting Questions.

(*Note.* — It is desirable that questions should be given in such an order as to form a systematic and progressive development of the subject, and so varied as to cause the same facts to be viewed in different aspects and relations and to require a different form of language in the answer. Hence it is that good teachers do not allow themselves to be fettered with the set questions of a text-book, however good they may be in themselves. Instead of formal questions, therefore, a series of suggestive points or heads for questions is appended to each prominent division of the text.)

1. Object of experiment and investigation; what stimulates inquiry.
2. Utilizing knowledge of structure and function; arbiters of our own health.
3. The subjects of study. 4. Anatomy defined; the microscope and dissection.
5. Increased knowledge and accuracy; surgical skill, operations.
6. Physiology defined; experiments on animals. 7. Animal and vegetable physiology.
8. Hygiene defined; medicine and hygiene contrasted. 9. Scope of health science; tributary sciences.
10. Simple substances or elements. 11. Composition of the body; proximate principles.
12. Classes of proximate principles in body. 13. Constant change and renewal; elements in food; distribution by blood.
14. Hunger and thirst. 15. Cell structure; a cell; nuclei; protoplasm; multiplying of cells.
16. Tissue. 17. Classes of bodily tissue, peculiarities.
18. Fluids, quantity, location. 19. An

organ; a system. 20. The various systems and their functions. 21. Cognizance by hygiene of causes, etc.; necessities where mankind is congregated; sanitary regulations; ignorance of the individual, danger. 22. Individual culture of health important; disease and ignorance; knowledge required by the individual, special.

THE OSSEOUS SYSTEM, OR SKELETON.

CHAPTER II.

COMPOSITION AND STRUCTURE OF BONE, ETC.

1. **Composition of Bone.** — Bone is composed of organic and inorganic matter, or in other words of animal and earthy matter. The animal matter is largely gelatine; the earthy is principally phosphate of lime, with some carbonate of lime and small portions of other earthy material.

2. The proportion of animal and earthy matter varies with the age of the person. In infancy the animal matter predominates, the bones being soft and constituted chiefly of cartilage in which earthy matter is afterward deposited. Later in childhood the animal and the earthy matter are about equal, each forming one-half the weight of the bone. In adult life, or in middle age, about four-fifths of the bone is earthy; in extreme old age the bones are still more largely composed of mineral matter.

3. The bones of the very young, composed largely of gelatine, will frequently bend instead of break when subjected to violence, and hence are liable to be distorted by confinement in improper positions or by pressure upon them. In adult life the bones are strongest and firmest, though retaining a degree of elasticity. In old age the

bones become very brittle and liable to fracture, and when broken heal slowly and often with difficulty. Thus are shown the uses of the composing materials—the earthy material giving firmness, and the animal matter tenacity and elasticity to the perfectly developed bone.

4. In healthy bone the proportions of organic and inorganic matter are such as to give elasticity combined with sufficient firmness. In the disease called *Rachitis* or “Rickets,” there is a deficiency of the earthy matter, and the bones being therefore too pliable and soft, deformities ensue, such as bow-legs, badly formed arms, ribs, etc.

5. **Structure of Bone.** — Excepting the joint surfaces, which are covered with cartilage, the bones are covered with a thin, tough, white membrane, known as the *periosteum* (Gr. *peri*, around; and *osteon*, bone), or bone-covering. This membrane adheres very closely to the bone, and in it ramify the blood vessels which supply nutrition to the bone.¹ From these blood vessels smaller branches penetrate into the substance of the bone through small apertures called Haversian canals (from Havers, the anatomist, who discovered them).

6. As the periosteum is the source from which the bone receives its supply of nourishment or building material, a portion of bone or even an entire bone may be removed, and, if the periosteum is saved intact and in place, new bone will be developed and replace the bone removed. As an example, we cite the case of a woman whose lower jaw-bone having become diseased, it was found necessary to remove it. The operation, performed by the late Dr. James R. Wood, of New York, was successful; the peri-

¹ When a bone is severely bruised, inflammation sometimes takes place in the bone-covering and a painful *felon* results.

osteum being saved and kept in place, a new jaw-bone was produced in due course of time.

7. The *long bones* are composed externally of a dense layer of bone tissue, ivory-like in texture, enclosing a hollow space or canal. Their extremities are widened to form the joint surfaces, and are covered with cartilage. The hollow shaft is filled with a pinkish, fat-like substance called *marrow*. Blood vessels ramify through it and furnish nourishment to the inner surface of the shaft. Designed to serve as columns or as levers, the long bones are admirably adapted to this purpose. Their hollow form gives lightness, and, at the same time, greater strength than the same amount of bone would have in a solid form of equal length.

8. The *short bones* are composed of a hard, ivory-like layer externally, and are softer or spongy in texture within. They are comparatively light in weight, and are found in parts where only a limited motion is required.

9. The *flat bones* comprising those of the skull and other cavities, are composed of two layers of hard bone tissue which enclose spongy bone substance. They are adapted to surround and protect various internal organs of the body.

10. **Cartilage.** — The *cartilages* belong to the bony system, and are what might be called fibrous tissue in a state of change to bone substance; but all cartilage is not destined to be changed into bone tissue. Cartilage is tough, elastic, flexible, and either yellowish-white or pearl-white in color. It forms the surfaces of bones in movable joints, furnishing a smooth, glistening surface, and unites bones at points where the frame-work must yield to expansion, as in the chest. It also forms the flexible skele-

tons of certain parts, as those of the external ear, nose, eyelids, etc.

11. Growth and Repair of Bone. — There is a vast difference between living bone and dead bone. We usually obtain our ideas of the bones comprising the human frame from the dried, bloodless specimens we see in museums and lecture rooms. Living bone, being well supplied with blood by the blood vessels of the periosteum and the marrow, is of a pale pink color on the surface, and deep red within.

12. At the ends of the smaller canals of the bone lie the little cells, and these absorb nourishing and repairing material from the blood. The bones are built up, and eliminated particles are replaced by others, in the same way that the nourishment and repair of the softer tissues are accomplished. The cells of the bones have the special function of selecting from the blood that which is necessary to form bone tissue.

13. The constant change of particles in the tissues can be easily demonstrated by the change of color that may be produced in bone by mixing *madder* with the food of animals. The bones soon become red. This color disappears when the coloring matter is withheld for a time, but reappears when the food is again colored.

14. Repair of Broken Bone. — A broken bone is healed by the active work of the cells that remain uninjured.

When the ends or edges of the fragments are properly placed together or "set," healing proceeds by a natural process, the bone being repaired in the same manner in which it grows. The cells send out first a watery fluid between and about the fractured ends. In the course of a few days this fluid becomes thicker, more jelly-like, and is gradually hardened by mineral matter which the cells

deposit. In a few weeks the deposited matter becomes firm enough to hold the bones in place. The new material deposited does not, however, become as hard and firm as the old bone for several months, and hence it is requisite to exercise care in the use of the injured bone during that period.

15. The process of healing varies in length of time with the age and general condition of the individual, being more rapid in the young than in the old. In advanced age fractures are sometimes exceedingly slow in reuniting, and in some cases union cannot be effected at all: in this way is indicated the general decline of the vital reparative processes in the aged.

CHAPTER III.

THE SKELETON.

1. **The Skeleton and its Functions.** — The word *skeleton* (from Gr. *skello*, to dry) signifies literally the dry or hard parts of the body. When used ordinarily, it applies merely to the bones; but in a broader sense it includes not only the bones, but the cartilages and membranes which complete the framework of the body. By some anatomists the teeth are also considered as belonging to the skeleton.

2. The skeleton serves as a basis of support for the soft parts, affords surfaces of attachment for muscles, protection for many delicate organs, and gives general outline to the body. The bones composing it vary in size and shape according to their location and office, and are bound together by fibrous bands, called *ligaments*. In the adult there are about two hundred separate bones, not including

the teeth and the small bones of each ear. In the child they are more numerous; and in the process of development of the skeleton, certain bones become united.

3. For convenience in classification the bones are divided into those of the *head*, *trunk*, the *upper* and the *lower extremities*. The head has twenty-two bones, the trunk fifty-two, the upper extremities sixty-four, and the lower extremities sixty-two.



Fig. 2. — The Skull (Front View).

1, frontal bone; 2, parietal bones; 3, temporal bones; 4, portions of the sphenoid bones, forming the backs of the orbits of the eyes; 5, nasal bones; 6, superior maxillary bones; 7, inferior maxillary bone; 8, malar or cheek bones.

4. **The Head.** — The bones of the head are subdivided into those of the *cranium* or skull, and those of the *face*; of the former there are eight, and of the latter fourteen.

5. The *bones of the skull* are separate in infancy and childhood; but in the adult they become firmly united by irregular, immovable joints called *sutures* (Lat. *sutura*, from *suere*, to sew or stitch), and thus form a strong, rounded case for the lodgement and protection of the brain and the organs of the special senses. These bones have been named according to their shape or location, as follows: the *occipital* bone, at the back and base of the skull, contains an aperture for the passage of the upper part of the spinal cord, and sends off two projections which join with the first bone of the spine to provide for the nodding movement of the head; the two *parietal* bones form the sides and top of the skull; the *frontal* bone forms the front of the skull and parts of the cavities of the nose and the orbits of the eyes; the two *temporal* bones form part of the sides and base of the skull, and contain the cavities of the organ of hearing; the *sphenoid* bone, resembling a bat with outstretched wings, forms the central portion of the base of the skull; the *ethmoid* bone, located in the front part of the base of the skull, forms part of the cavities of the nose and the inner boundaries of the orbits of the eyes. In addition to these are the four small bones of the middle cavity of the ear.

6. The inner surface of these bones is marked with numerous elevations and depressions which correspond with similar inequalities on the surface of the brain.

7. The *bones of the face* comprise two bones of the bridge of the nose, two lachrymal bones at the inner angles of the orbits of the eyes, two cheek-bones, two bones of the

upper jaw, one of the lower jaw, two of the palate, two turbinated or scroll-like bones in the cavity of the nose, and the vomer, or plough-share, the thin sheet of bone

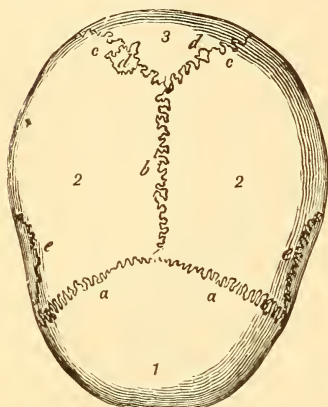


Fig. 3.

EXPLANATIONS.

- a, a*, the coronal suture.
- b, b*, the sagittal suture.
- c, c*, the lambdoidal suture.
- d, d*, *ossa triquetra*, small ragged bones, occasionally found in some skulls, lying in the last-mentioned suture.
- e, e*, portions of the *temporal bone*, overlapping the walls.
- 1, the *frontal bone*,
- 2, 2, the *parietal bone*.
- 3, the *occipital bone*.

which separates the cavities of the nose. These bones unite with the bones of the skull, and form the cavities in which the organs of sight, hearing, taste, and smell are placed.

8. The Teeth. — Although the teeth are not commonly classed as bones, they apparently belong to the osseous system. They differ greatly in size and form. Those in the front of each jaw have sharp chisel-like edges, are thus well adapted to biting or cutting, and are called *incisors* (Lat. *incido*, I cut). Next to these in each jaw and on each side is a single pointed tooth, called the *canine* (Lat. *canis*, dog) because its form and position in the human jaw correspond with the similar tearing teeth of the dog and other flesh-eating animals. Beyond the canine teeth on each side is a pair of *bicuspid*s (Lat. *bis*, twice ;

and *cusps*, a point), so called because of two ridges on the crown of each tooth. Still beyond are larger teeth, each having a broad, irregular, grinding surface, and these are called *molars* (Lat. *mola*, a mill).

9. At birth the teeth are undeveloped, but during the first two or three years of childhood twenty *deciduous* or temporary teeth are developed. Of these eight are *incisors*, four *canine*, and eight *molars*. At the age of about seven years the temporary teeth begin to be cast off, their places being taken by the *permanent teeth* which grow beneath them; and by the twelfth or thirteenth year all have in this way given place to the second, or permanent set.

10. The *permanent teeth* of the adult number thirty-two. In each jaw there are four incisors, two canines, four bicuspids, and six molars. The last molars, however, do not appear till between the eighteenth and twenty-first years, and occasionally one or other of them may not appear till several years later. This fact has caused these latter to be called "wisdom teeth."

11. A tooth is composed of four distinct substances, viz., the *pulp*, the *dentine* or ivory, the *enamel*, and the *cement*. The cavity of the tooth contains a very soft substance, the *pulp*, which consists of a mass of minute blood-vessels and nerves that enter through an opening at the point of each fang. The *dentine* or ivory (Lat. *dens*, a tooth), which envelops the pulp, resembles bone, but contains much more mineral matter, and is consequently harder.

12. The dentine, which forms the crown of the tooth, is overlaid with the *enamel*, the hardest substance in the body, containing only two or three per cent of animal

matter. The root of each tooth is surrounded by the *cement*, a substance softer than dentine, and which resembles bone in structure, though it has no Haversian canals.

13. It has already been intimated that the different classes of teeth are adapted for different modes of action. The variety of action is increased by the movement of the lower jaw. In biting our food, the jaw moves perpendicularly and brings into use the front or incisor teeth. After being severed by the incisors, the food is passed to the molars to be crushed and ground, and this grinding could not be thoroughly accomplished if the lower jaw were capable of a vertical motion only. While grinding the food it may be observed that the jaw moves a little to the right and left, and also backward and forward, these movements causing the surface of the molars to slide over each other, and thus to grind the food that may be between them.¹

CHAPTER IV.

THE SKELETON (*continued*).

1. **The Trunk.** — The bones of the *trunk* comprise the *spinal column* or backbone, the *ribs*, the *sternum* (Gr. *sternon*, the breast) or breast-bone, and the *hyoid* bone at the root of the tongue. There are twenty-six bones in the spinal column, twenty-four ribs, one sternum, and one hyoid bone.

¹ The carnivorous animals have not broad molars; they bite and tear the flesh on which they feed, the general motion of the jaw being up and down only. On the other hand, herbivorous animals have large, broad molars, and the jaw has a much greater variety of movement than that of the human being.

2. The *spinal column* consists of a series of irregular bones, twenty-four of which are called *vertebræ* (Lat. *verto*, I turn). The lowest two are called the *sacrum* (Lat., sacred) and the *coccyx* (Lat., cuckoo). There are originally thirty-three separate *vertebræ* in the column, and the upper twenty-four commonly remain distinct throughout life; but the bones from the twenty-fifth to the twenty-ninth, inclusive, early unite into one large bone, the *sacrum*; and the four remaining *vertebræ* often fuse into one mass, the *coccyx*.

3. The *vertebræ* are so united as to form a long, flexible column, which serves as a centre or axis with which all the other bones of the frame-work are connected. The base of the skull rests on the uppermost bone of the column, the lower extremity of which is wedged in between the bones of the hips.

4. The uppermost seven bones are called *cervical vertebrae* (Lat. *cervix*, the neck). The next twelve are named *dorsal vertebrae* (Lat. *dorsum*,

EXPLANATION.

Longitudinal section of the Spinal Column, viewed from the right side.—C to D, *cervical vertebrae*; D to L, *dorsal vertebrae*; L to S, *lumbar vertebrae*; S to Co, *sacral vertebrae*; Co to 4, *coccygeal vertebrae*. In life, the spaces between the bones are occupied by cushions of cartilage.



Fig. 4.

the back). The remaining five movable bones are termed *lumbar* vertebræ (Lat. *lumbus*, the loin), these latter being the largest of the series. Their bodies are broad and thick and closely interlocked by broad plates extending down from behind and at their sides.

5. The *sacrum*, so called from its having been anciently offered in sacrifice and hence considered sacred, is the wedge-like bone next below the lumbar vertebræ and between the hip-bones.

6. The *coccyx*, so named from its resemblance to the beak of a cuckoo, is the slender appendage of bone forming the lower end of the spinal column. An extension of the coccyx constitutes the flexible tail in some of the lower animals.

7. A *vertebra* consists of a body from which spring two

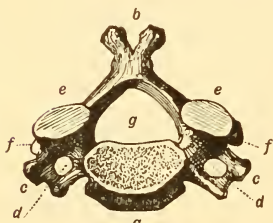


Fig. 5.

EXPLANATION.

This is an accurate drawing of one of the bones of the spine, at the neck.

a is the *body* of the bone.

b, the *spinous process*, or handle, which gives the name of spine to the whole column.

c, c, the *transverse processes*, to which the muscles adhere, producing motion.

d, d, round holes, through the arms of the bone, for safely lodging an artery, which carries blood to the brain.

e, e, the upper, and *f, f*, the under, surfaces, which

make a joint with the blocks above and below it.

g, the hole through which the spinal marrow, or pith of the back, passes in safety from the head, through the whole chain of twenty-four vertebræ.

arches that unite in such manner as to form a ring. From the outer edge of this ring three processes or *spines* are given off, one at the back and one at each side. These spines afford places of attachment for ligaments and for muscles that bend the back, etc. Though the vertebræ of the various regions of the column differ in certain details,

they resemble each other so greatly that, for our purpose, a general description of one will serve for all.

8. The vertebral bones are united by disks of elastic cartilage interposed between them, thus rendering the column flexible and lessening shock from blows and jars. In advanced age, these cartilages become harder and less elastic, and hence the back bends with less ease.

9. It will be evident that the vertebræ arranged in a column and bound together by strong ligaments will not only afford powerful and flexible support, but that the space in the centre of the bones, in the continuity of the column, forms a long tube. This tube, called the *spinal canal*, lodges the great trunk-nerve known as the *spinal cord*, and affords it strong and much-needed protection.

10. A side view of the *spinal column* shows it to be curved somewhat like the letter *f*, but when viewed from back or front there is no lateral curvature. The curves of the column add to the safety of the brain in the jolts and jars to which the body is liable, the shock of a fall or of a leap being divided in force at each curve, instead of being transmitted directly, as would be the case if the column were straight; and further, the curve at the back serves to increase the cavity of the chest, giving space for the expansion of the lungs; at the loins the forward curve operates to give better support to the contents of the abdomen.

11. In each of the vertebræ there are notches which, when the bones are in place, form little canals that give passage to nerves that spring from the spinal cord and are distributed to the various parts of the body: other similar channels provide safe passage for blood vessels.

12. **How the Head turns.**—The head is enabled to turn

right or left on the spinal column by means of mechanism briefly described as follows: The second vertebra of the neck, the *axis*, has a peg-like projection (the *odontoid process*) which extends upwards and forms an axis on which the uppermost vertebra, the *atlas*, turns, its front, inner surface being kept in position against the peg by a strong ligament. In turning, the head and the atlas-bone move together without danger of falling either forward or backward, an accident which would immediately destroy life by crushing the spinal cord.

13. The Thorax or Chest. — The *ribs*, twenty-four in number, twelve on each side, are divided into two general classes,

the *true* and the *false*. They are all attached by movable, flexible joints to the vertebræ behind, and the uppermost seven on each side, the *true ribs*, are separately united by bands of cartilage to the breast-bone in front. The remaining five on each side are called the *false ribs*, and of these the uppermost three are joined together in front by a common cartilage and by it to the breast-bone. The last two on each side are free in front, and hence are

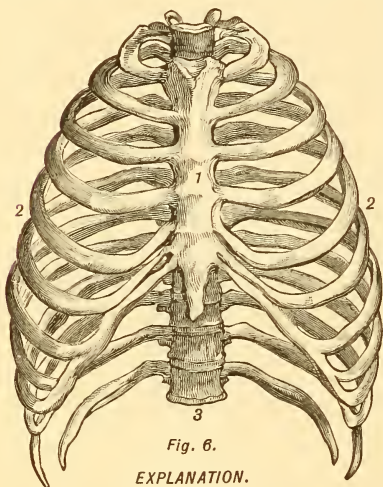


Fig. 6.

EXPLANATION.

Framework of the Chest as it appears when not distorted by tight lacing. — 1, the sternum or breast-bone; 2, 2, the ribs; 3, the spinal column.

known as *floating-ribs*. In general the ribs are flat and curved, and gradually increase in length from the first to

the seventh. They incline forwards and downwards from the backbone, so that when alternately raised and depressed in breathing, the capacity of the chest is correspondingly increased or diminished.

14. The ribs, the breast-bone, and the upper portions of the backbone together form the elastic, bony frame-work of a cage, the *thorax* or *chest*, which surrounds and protects the heart, lungs, and large blood-vessels. The interstices of this cage-like structure are filled with muscles which cover and form with it the walls of the chest.

EXPLANATION.

This figure represents the *sternum*, or breast-bone.

A, the place where the collar-bone is joined.

C, where the first rib is joined.

c, d, e, f, g, the number of pieces which are united into one.

h, the tip of the sternum.

15. The *sternum* (Gr. *sternon*, the breast), or breast-bone, is flat in shape and spongy in texture. It affords attachment for the cartilages of the ribs, and completes the formation of the chest in front. Originally it consists of several bones, which ultimately become united in one.

16. The size of the arches formed by the pairs of ribs increases from above downwards, the shape of the chest being that of a cone, the base being downwards. At least this is its shape when not deformed.

17. The *hyoid* bone at the root of the tongue received its name from a fancied resemblance to the Greek letter *Upsilon*, whose shape is somewhat similar to that of a

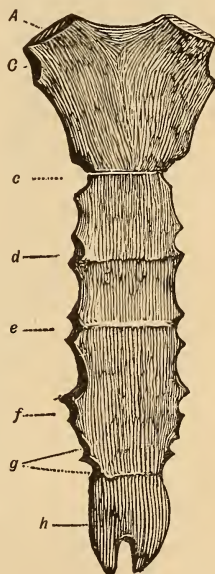


Fig. 7.

horse-shoe. It provides attachment for a number of muscles of the neck and tongue.

18. The Upper Extremities. — The upper extremities are the long, jointed appendages attached to the upper part of the trunk, and commonly called the *arms*. Together they contain sixty-four bones, thirty-two on each side, and these are classified as bones of the *shoulder, arm, forearm, wrist, and hand*.

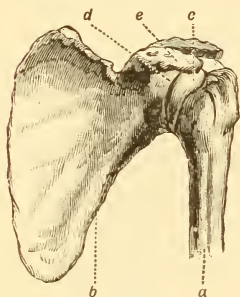


Fig. 8.

EXPLANATION.

In this cut is seen the union of the head of the humerus with the shallow socket of the scapula. These bones are represented as detached from the body, and the view is a front one.

a, the *humerus*, or arm-bone.

b, the *scapula*, or shoulder-blade.

c, the head or ball of the *humerus*.

d, rim of the socket of the *scapula*.

e, processes of bone that overlap and protect the joint.

19. Each shoulder contains two bones, the *clavicle* (Lat. *clavis*, a key), so named from its resemblance to an ancient key, and commonly known as the collar-bone; and the *scapula* (Lat., the shoulder) or shoulder-blade, the broad, flat, triangular bone at the top and back of the chest. One end of each clavicle joins the top of the breast-bone, and the opposite end joins the shoulder-blade, thus acting as a brace to prevent the shoulder from inclining unduly toward the chest. The scapula has no joint with the chest, but is held in position by strong muscles which cross and overlap it in various directions; it is movable in a variety of directions. A shallow cavity in each scapula receives the rounded head of the bone of the arm, and with it forms the *shoulder-joint*. Bony projections over-

lap the joint, give it additional security, and afford attachment for ligaments. The shallowness of the cavity of the shoulder-joint gives it the greatest range of movement, but also renders it more liable to dislocation.

20. The *arm* (upper-arm) contains one long bone, the *humerus* (Lat., the arm), enlarged at its extremities to provide joint surfaces at the shoulder and the elbow. The shaft of this bone is surrounded by powerful muscles which use it as a lever.

EXPLANATION.

All the bones of the arm, fore-arm, and hand, are here exhibited in connection, with reference to impressing it on the mind, after having read a short description of the individual parts of the upper extremity.

a is the head of the arm-bone, articulated to the shoulder.

b, the joint, or elbow, formed by the *ulna* and lower end of the arm.

c, the shaft of the *os humeri*, or arm.

d, the *radius*, or handle of the hand, united solely to the wrist.

e, the *ulna*, which alone forms with the arm the joint.

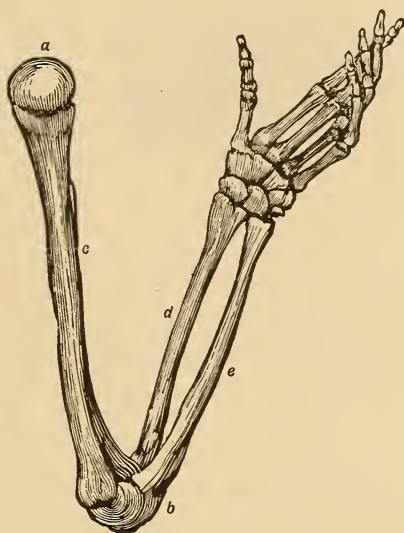


Fig. 9.

21. The *fore-arm* has two bones, the *ulna* (Lat., the elbow) and the *radius* (Lat., a ray or a spoke), which extend from the elbow to the wrist. In addition to entering into the formation of the elbow-joint, they join the *carpal* bones to form the wrist-joint, and with each other at both extremities in such a way as to admit of the rotary motion of the hand. The ulna (the bone on the little-finger side of the arm) enters principally with the

humerus in forming the elbow-joint, as the radius does not touch the humerus till the fore-arm is drawn up to the arm. The radius, however, is so expanded as to enter principally into the formation of the wrist-joint. In the rotary motion of the hand, the radius twists or glides over the ulna when the palm is turned upward or downward, and when the thumb is uppermost the bones are parallel.

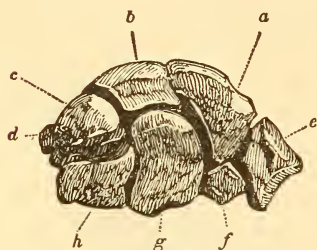


Fig. 10.

EXPLANATION.

Another plan of the bones of the wrist, showing them placed in two rows. This is a back view of the carpus of the right hand.

a, the boat-shaped bone ;

b, the half-moon shaped ;

c, the wedge-shaped ;

d, the pea-shaped ; which make the upper row, joining the fore-arm.

In the second row are the four others, *e, f, g, h*, which are united by a joint to the palm of the hand.

22. The *wrist* has eight small, irregular, solid bones, bound together in such a manner as to give freedom of motion and great strength. They are called *carpal* bones (Gr. *karpōs*, the wrist), and are arranged in two rows of four each. The rotary motion of the radius and the flexibility of the wrist give the hand great variety of movement.

23. The *hand* contains nineteen bones, five being in the palm and fourteen in the fingers and thumb. The bones of the palm are called *metacarpal* bones (Gr. *meta*, beyond ; and *karpōs*, wrist), and those of the fingers and thumb, *phalanges* (Gr. *phalanx*, a rank), three of which form each finger, and two each thumb. The number, varying length, and numerous joints of the fingers and thumb render the hand a wonderful instrument for grasping large objects and for picking up small ones. Some writers have ex-

pressed the opinion that man is indebted mainly to his hand for his superiority over the rest of the animal creation. Its perfection, however, would be useless in the absence of intelligence adequate to the direction of its operations.

24. The superiority of the right hand, in most instances, is well known. It has been argued that its properties are due to the more direct and forcible supply of arterial blood to the right arm; also that its superiority is the result of the more frequent exercise of the right hand. The distinction pertains, however, to the whole right side of the body. The left side is not only weaker in muscle, but also in vital or constitutional properties. The organs of motion of the right side are usually better developed than those of the left, and disease attacks the latter more frequently. An equalized motion of the body is seldom seen in walking; the tread of the left foot is usually less firm, a greater push is made by it, and the toe is not so much "turned out" as in the right. Exercise and training of the left extremities are especially necessary to compensate for anything lacking in natural endowment.

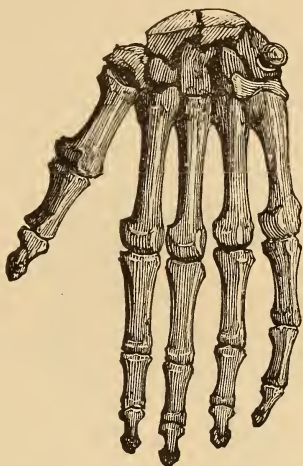


Fig. 11.

EXPLANATION.

Here is presented a back view of all the bones of the hand as they are connected with the eight little bones of the wrist.

CHAPTER V.

THE SKELETON (*concluded*). — HYGIENE OF THE BONES.

1. **The Lower Extremities.** — The lower extremities are, like the upper extremities, long and jointed; they are commonly known as the *legs*, and are united to the lower end of the spinal column by means of the bones of the hips.

2. Each *lower extremity* is divided into a *hip*, *thigh*, *leg*, *ankle*, and *foot*; together the lower extremities contain sixty-two bones, one bone entering into the formation of each *hip*, one in the *thigh*, three in the *leg*, seven in the *ankle*, and nineteen in the *foot*.

3. The *hip-bones* are also called the *innominate* bones (Lat. *in*, not; and *nomen*, a name); each contains a deep, cup-like cavity on the external surface, into which the rounded head of the thigh bone fits to form the hip-joint. The broad, bony basin formed by the hip-bones and the sacrum is called the *pelvis*, which supports the internal organs of the lower part of the trunk, and is in turn supported like a bridge, the legs being the pillars.

4. The *femur* (Lat. *femur*, the thigh) or *thigh-bone* resembles the humerus of the arm in general form, but is much larger and stronger. At its upper extremity is a sphere-like head supported by a neck forming an obtuse angle with the body of the bone. The head of the femur is not entirely enclosed by the cavity of the hip-bone. An elastic rim of cartilage increases the size of the cavity,

and embraces the head of the femur so closely as to hold it in place by atmospheric pressure. But this cartilage alone would be insufficient to prevent displacement, and hence two ligaments hold the ball of the femur firmly in its socket. One of these, in the form of a short cord, lies within the joint and connects the ball with the centre of the socket; the other is outside the joint, and surrounds it like a cap or bag.

EXPLANATION.

We have here an excellent representation of the upper end of the *femur*, or thigh-bone, and half of the *pelvis*. The ball, or head, of the femur, supported by a neck which forms an obtuse angle with the body of the bone, is fixed in the socket of the *os innominatum*, filling the cavity, but not all enclosed by it. The depth of the socket is only about half the diameter of the ball.

a, the *os innominatum*, or hip-bone.

b, the head of the *femur*, or thigh-bone.

c, the rim of the socket.

d, the *femur*.

e, the *sacrum*.

f, the point of bone on which we sit.

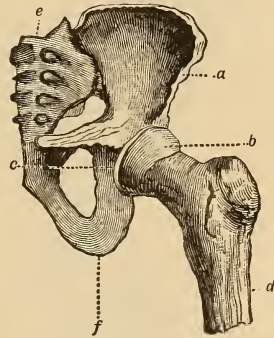


Fig. 12.

5. The *hip-joint*, like that of the shoulder, permits movement in almost every direction, though not so freely as the latter, while the depth of its socket provides greater security against dislocation. Violent twistings of the limb, however, frequently force the ball from the socket.

6. The *leg* has three bones, the *tibia* (Lat., a pipe or flute), the *fibula* (Lat., a clasp), and the *patella* (Lat., a little plate). The *tibia*, or shin-bone, is the largest, and gives the main support for the weight above it, as it alone enters with the femur into the formation of the knee-joint, and with the *tarsal* bones principally forms the ankle-joint. The *fibula* is the long, slender bone, firmly bound

at both ends to the outer side of the shin-bone, its lower end forming the external side of the ankle-joint.

7. The *knee-joint* is formed by the two rounded ridges of the lower extremity of the thigh bone being received

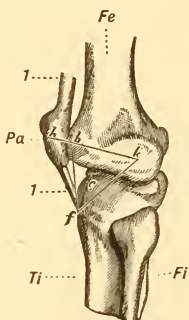


Fig. 13.

THE KNEE-JOINT.

Fe, the femur, or thigh-bone; *Ti*, the tibia, or shin-bone; *Fi*, the fibula, or slender bone of the leg; *Pa*, the patella, or knee-pan; 1, 1, ligaments that sustain the patella.

into corresponding grooves in the upper end of the shin bone. Cartilages on the joint surfaces provide smoothness and diminish the jars to which the joint is liable, and strong ligaments within and without bind the bones very firmly together. In front of the joint is the *patella* or knee-cap, a chestnut-shaped bone held in place by the broad tendon of a muscle, and not directly joined to the bones beneath it. This bone acts as a shield to the knee-joint, whose prominence and peculiar liability to injury from falls, and in various other ways, require this additional means of protection.

8. The *ankle*, situated at the lower extremities of the bones of the leg, contains seven short, irregular bones, called *tarsal* bones (Gr. *tarsus*, the ankle). The extremities of the leg bones united form a mortise, and into it receive one of the bones of the ankle, thus forming the *ankle-joint*. Strong ligaments here again bind the bones together. The movements of this joint are not so free as those of the wrist. The joint is peculiarly liable to sprains from rough twistings intensified by the weight of the body.

9. The *foot* contains nineteen bones, viz., the five *metatarsal* bones (Gr. *meta*, beyond; and *tarsus*, ankle) or

bones of the instep, and the fourteen *phalanges* in the toes. The bones of the instep of the foot are similar to those of the palm of the hand, and are connected with the bones of the toes. The number of bones in the toes is the same as in the fingers and thumb, the great toe representing the thumb. All these bones are fastened together by ligaments.

"If the foot and the hand are varieties of the same type of organization, they present differences in regard to their respective uses ; the foot, designed to support the body, is

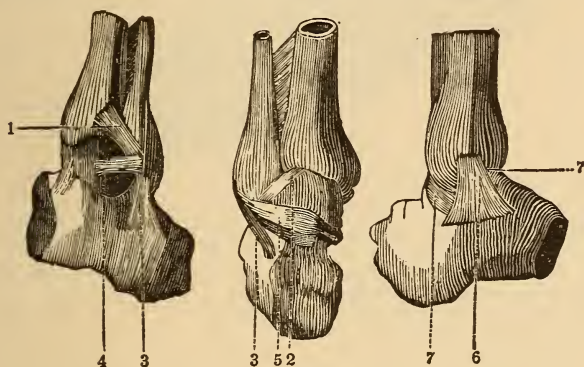


Fig. 14.

EXPLANATION.

These three plans show how the two bones of the leg are united above the ankle-joint. 1, 2, 3, 4, 5, 7, 7, 6, mark the ligaments which bind them firmly.

especially remarkable for its solidity ; in the hand, mobility is the predominating quality." The toes have neither the length of the fingers nor the extent and variety of their movements ; in a word, it is a *foot*, and not a hand as it is in the quadrumana. Its arched form gives great strength combined with elasticity.

10. Joints and Ligaments. — A joint is the union of two or

more bones with each other, and may be either *movable* or *immovable*. The latter class are few in number, and will be noticed later. The movable joints receive different names according to their characteristics, viz., ball-and-socket joint, hinge joint, pivot joint, mixed joint, and sliding joint.

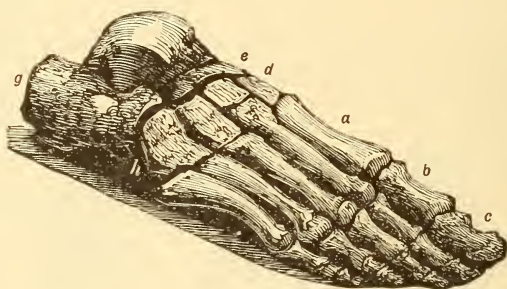


Fig. 15.

EXPLANATION.

By this diagram the skeleton of the foot will be clearly understood, even without the aid of the bones. Twenty-six bones are here so curiously grouped together, that an arch is made between the heel and ball of the great toe.

a shows the five bones of the *metatarsus*.

d, *e*, *g*, and *h* point out the bones of the instep, or *tarsus*.

b and *c* indicate the *phalanges*, or toes.

11. The *ball-and-socket joints* are those capable of moving in all directions. Of the ball-and-socket joint there are two examples in the shoulders and two in the hips.

12. The *hinge joints* are those in which the motion is limited to two directions, like that of the hinge of a door. The knee, elbow, and ankle present the largest examples of the hinge joint, and the joints of the toes, fingers, and jaw belong to the same class.

13. The *pivot joints* are those which admit of a rotary motion, as that of the *axis* bone of the spine which per-

mits of the rotary motion of the head, and that of the ulna and radius by which the latter bone rolls over the former.

14. The *mixed joints* are such as admit of slight motion and great strength. The joints of the spinal column by which the forward, backward, and lateral motions of the trunk are made possible, and those of the ribs, vertebræ, and sternum which admit of motion during respiration, are examples of mixed joints. In these joints motion is made possible by means of the elasticity and flexibility of the cartilages which enter into their formation.

15. The *sliding joints* are those in which the bones have a sliding or gliding movement, as seen in the ankle and the wrist.

16. The *immovable joints* are those in which the margins of the bones are almost in contact, and are incapable of motion on each other. Sometimes a thin membrane or a thin layer of cartilage is situated between the joint surfaces of the bones, but even these disappear in advanced life, and a complete bony union is formed. Examples of immovable joints are those of the skull, in which each bone has a very irregular, saw-like edge, and these edges interlock in joints called *sutures* (Lat. *sutura*, a seam). Most of the bones of the face are also united in immovable joints.

17. In all joints the bony surfaces which move upon one another are covered with *cartilage*, and between them there is a thin sac of membrane which covers or lines the cartilages and partially forms the side walls of the joints. This sac, called the *synovial membrane* (Gr. *syn*, together; *oön*, egg), secretes a small quantity of lubricating fluid, like the white of an egg, called the *syno-*

vial fluid, the office of which is to lubricate or moisten the joint surfaces.

18. The *ligaments* (Lat. *ligo*, I bind) are strong, white, fibrous bands which bind the bones together. Being more or less elastic, they allow the necessary freedom of motion and tend to prevent dislocation. The muscles are united to the bones by other white bands called *tendons* (Lat. *tendo*, I stretch), and these should not be confused with ligaments, which always bind bones together. Ligaments are sometimes circular and surround the joint on all sides, as in the case of ball-and-socket joints. In some instances ligaments are situated within the joints, as in the hip-joint, where the round ligament unites the ball of the thigh-bone and the bottom of the socket in the hip-bone; or as in the knee, in which the ligaments cross each other obliquely between the bones of the joint. In hinge joints the ligaments are chiefly accumulated at the sides of the joints.

19. The most perfect mechanism which man has been able to design and construct bears no comparison to the wonderful assemblage of apparatus comprised in the joints.

20. **The Envelope of the Skeleton.** — The strange outlines of the skeleton, the type of death, are covered by and caused to disappear beneath an envelope of muscles and teguments. The eyelids veil the orbit and protect the eye. The coverings of the nose complete its form, and protect the organs of smell. The lips, placed before the cavity of the mouth are at once an organ of prehension, an indispensable instrument in articulating sounds, and one of the most expressive features of the face. The external ear collects the sound waves, and gives expression to the

head. The hair of the scalp, the eyelashes, and the eyebrows protect the skull and the eyes, and, by their varying shades of color, undulations, and curves, contribute to the sightliness of the whole. Lastly, the skin, enlivened by the most delicate tints, and strengthened by more vigorous tones, forms the outer envelope of the rest of the body.

HYGIENE OF THE BONES.

21. Primary Requisites. — To be healthy, *bone*, like the other tissues, demands that a proper balance in the vital processes of the system shall be maintained. Suitable food, its proper digestion and assimilation, unobstructed circulation of the blood, the proper absorption and ultimate elimination of waste products, and sufficient exercise, are primarily essential to healthy bone structure.

22. Food that will supply in sufficient quantity and in due proportions the earthy and the animal constituents of bone is required. An undue preponderance of earthy matter gives to the bones brittleness, and renders them liable to be easily fractured; while a superabundance of animal substance causes them to be too flexible and to yield too readily under pressure or weight imposed upon them, thus producing distortion and deformity. Digestion must be unimpaired in order that the constituents of bone may be thoroughly abstracted from the food; the circulation of the blood must be normal in order that the elements held in solution shall be properly and sufficiently deposited; and exercise must be taken to stimulate digestion and the circulation, and to strengthen the muscles, by the contraction of which the bones are kept in natural position and the frame-work preserved from deformity.

23. Distortion through Faulty Position. — On account of the flexibility of bone and the readiness with which it yields in childhood, caution is always necessary to avoid continued pressure upon any of the bones and the production of permanent alterations in their shapes. Habitual faulty positions in sitting and in standing likewise tend to distortion of various bones, to "round shoulders," "hollow chests," and to improper curvature of the spine.

24. *Lateral curvature of the spine* is produced by abnormal muscular contraction in which the spinal processes on one side are drawn toward each other, and the cartilages between the bones are compressed on the concave side of the bent spine. This deformity is almost invariably the result of continued improper position. Those who lean to one side habitually, as for instance, with one arm elevated on a high desk at school, are the most liable to it. Weakening of the muscles of one side of the back, sufficient to prevent their action for some time, may be followed by permanent contraction of those on the opposite side, and consequent deformity. Shortening of one leg from any cause will also give rise to lateral curvature of the spine.

25. It is of the greatest importance that young people should always sit erect, allowing balanced muscular action, for careless habits of sitting are sure to result in some degree of spinal curvature and deformity, if not in disease. Properly regulated gymnastic exercises, calling into use the weakened muscles, may correct incipient curvature of the spine.

26. Distortion by Dress. — Through false notions of what constitutes symmetry of form, many consider a small waist to be a special mark of beauty and grace, and in order to

secure it resort is had to a process of compression analogous to that by which the women of China are caused to have small, and, according to their idea, beautiful feet. In

CONTRACTED CHEST.

An outline is here presented of the chest of a female, to show the condition of the bones, as they appear after death, in some women who have habitually worn tight stays.

All the false ribs, from the lower end of the breast-bone, are unnaturally cramped inward towards the spine; so that the liver, stomach, and other digestive organs in the immediate vicinity, are pressed into such small compass that their functions are interrupted, and, in fact, all the vessels, bones, and viscera on which the individual is constantly depending for health, are more or less distorted and enfeebled.

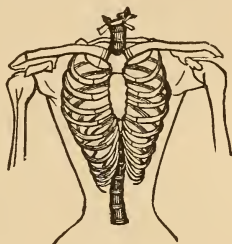


Fig. 16.

order to secure a small waist, girls are tightly laced before the bones of the chest are fully developed. This presses inward the lower ribs, so that which is naturally the largest part of the chest is made the smallest, and various internal organs are crowded out of place and so compressed as to interfere with their operations.

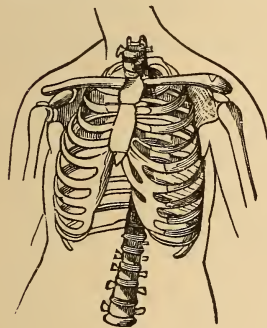


Fig. 17.

SKELETON OF A WELL-FORMED FEMALE CHEST.

By comparing the accompanying plan of a well-developed and naturally proportioned female chest, with the distorted skeleton appended to the preceding note, the difference is strikingly apparent. Here is breadth, space for the lungs to act in; and the short ribs are thrown outward, instead of being curved and twisted down towards the spine, by which ample space is afforded for the free action of all those organs which in the other frame were *too small to sustain life*. The first may be regarded as the exact shape and figure of a short-lived female; and this may be contemplated as an equally true model of the frame of another, who, so far as life depends upon a well-formed body, would live to a good old age.

27. The size of the chest being diminished, and the muscles that move the ribs being hampered and weakened by enforced inactivity, proper respiration becomes impos-

sible. Blood circulation is interfered with by pressure upon important blood-vessels, and the purification of the blood is retarded through insufficient breathing. When this process of lacing is persisted in, many of the natural functions of the body become seriously and permanently impaired.

28. Diseases of the Bones. — It would hardly be suspected from the appearance of bone, that, throughout life, and more particularly in early life, it is the seat of an active vital process, and that it is liable to inflammation, ulceration, and death, the same as the softer tissues of the body.

29. Inflammation of the periosteum and bones is often produced by direct injuries from falls and blows, or by the inoculation of specific poisons. A *felon* of the hand is a result of such injury and inflammation. When the affected bone lies close to the skin, redness and swelling are present, pus may form, and the severe throbbing pain will continue for a long time. Rest and hot fomentations are necessary from the start, and surgical treatment should be employed.

30. Ulceration of the bones, or caries, is a result of inflammation. As the ulceration progresses, destruction of the bone tissue results in the formation of matter which gradually works its way to the surface and is discharged through openings in the skin. If the diseased condition is allowed to continue, the bone becomes so affected that its usefulness is destroyed. An operation which consists in scraping the bone to remove diseased tissue is required, as no other treatment will arrest the progress of the disease.

31. Death of a large portion of bone, or as it is technically

termed, *necrosis*, is sometimes one of the terminations of inflammation. A large section of dead bone is separated from the rest of the bone, and thus becomes a foreign body which nature makes an effort to throw off, as in the case of ulceration. As it would require months or years to accomplish this removal by natural processes, surgical skill removes it in a few minutes by a simple operation, and with proper after-treatment, new bone is produced.

32. *Softening of the bones* may take place after inflammation, or from deficiency of earthy material. This condition of the bones is most frequently encountered in children, the bones of the legs bending from the weight of the body and producing a deformity called "bow-legs." In the disease called *rickets*, the bones are similarly soft, but there is a deficiency of both animal and earthy matter in the bones. These deficiencies must be supplied by food that contains the lacking constituents in abundance. When deformity has developed, mechanical appliances should be attached to the leg and foot to aid in reducing the unnatural curvatures.

33. **Sprains, Dislocations, and Fractures.** — A *sprain* is a torn or stretched condition of the ligaments of a joint, commonly caused by falls, blows, or sudden wrenching. When severe, a sprain may prove more serious than either a dislocation or a fracture. The treatment of sprains requires absolute rest of the injured part. When the injury first occurs, cold applications will often prevent inflammation. After swelling has taken place hot fomentations should be applied, and the limb kept in an elevated position. Neglected sprains are liable to lead to serious chronic diseases of the injured joints.

34. A *dislocation* is a separation of the extremities of

bones that form a joint, and may result from external forces, or from muscular contraction. The indications of a dislocation are deformity of the joint, loss of function, and the absence of the grating sound heard in fractures. A dislocation should be reduced before much swelling takes place.

35. *Fracture* of a bone may be produced by various external violence or by muscular contraction. Grating sounds and sharp pain at the point of injury when the part is moved, mobility where there should be no motion, and deformity of the part, point conclusively to the occurrence of a fracture. The bones should be restored to their natural positions and fastened there with suitable bandages, promptly and before inflammation begins. If a surgeon cannot be had at once, the injured person should be placed on a board or shutter, the injured part disposed in the most comfortable position possible, and then conveyed to his home. After the bones have been set and the splints and bandages applied, the dressings should not be disturbed in the absence of a surgeon. The process of healing varies in time required according to the age and general condition of the individual. Usually about two months is required, and the injured part should be excused from duty during this period, and employed with caution for some time thereafter.

36. *Care of the Teeth.* — By the *teeth* the food is divided and ground and thus adapted for the action of the gastric juice of the stomach. “Bolting” of food is often the beginning and cause of serious digestive disorders. Hence attention to the health of the teeth, by keeping them clean and in good order, is a measure which undoubtedly tends toward the prevention of disease.

37. Particles of food allowed to collect and remain lodged between the teeth, decay and generate acids which attack the substances of the teeth and decompose them. Such particles should be thoroughly removed by means of a thread or by a wooden tooth-pick, after eating, and the teeth should be well brushed both on their inner and outer surfaces, as frequently. A moderately hard and broad brush should be used; and as fluids are not sufficiently effective in cleansing the teeth, a powder or dentifrice must be used. The fine precipitated chalk, or magnesia, forms a safe, agreeable, and effective tooth-powder. When the gums are tender, a small quantity of tincture of myrrh may be added to water and used as a mouth wash. On the first indications of decay, the dentist's services are necessary; and when the natural teeth have become unfit to perform their highly necessary work, there should be no delay in procuring efficient artificial substitutes.

Suggested Points for Questions.

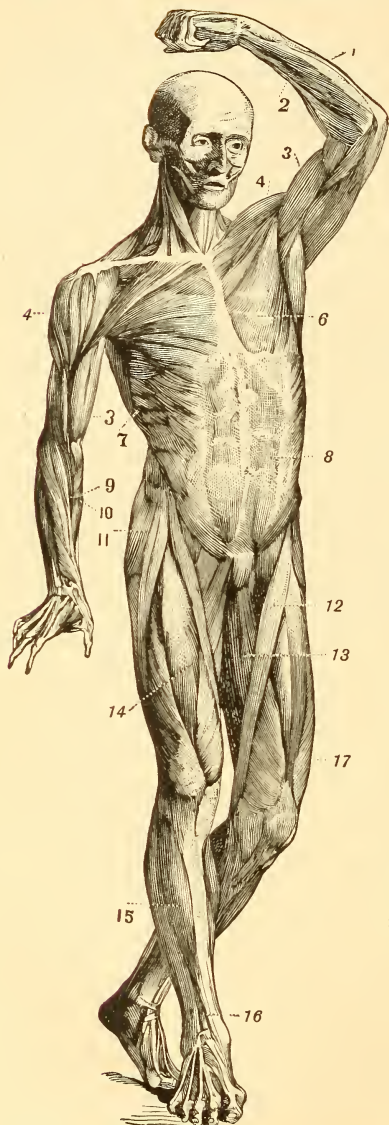
CHAPTER II. — 1. Composition of bone, organic and inorganic. 2. Proportions of animal and earthy matter at different ages. 3. Bones in youth, distortion; bones in the adult, strong; bones of the aged, brittle. 4. Elasticity and firmness; "Rickets," etc. 5. Bone coverings; periosteum; Haversian canals and blood-vessels; nutrition of bone. 6. Reproduction of bone when removed. 7. Structure of long bones, extremities, shaft, marrow, lightness, strength. 8. Short bones, structure, location. 9. Flat bones, layers, adaptation. 10. Cartilages, texture, color, uses. 11. Living bone and dead bone. 12. Cells of the bones, where; nourishment, how accomplished. 13. Change of particles, demonstrated — *madder*. 14. Uninjured cells and healing; time and care required. 15. Influence of age on healing; general decline indicated.

CHAP. III. — 1. The term *skeleton*; application of. 2. Functions; size and shape of bones; ligaments; number of bones; union of separate bones. 3. Divisions of skeleton, number of bones in each. 4. The head, divisions of. 5. The skull in infancy; sutures; bones of skull—location. 6. Inner surfaces. 7. Bones of face; relation to skull. 8. The teeth, classes, peculiarities, uses. 9. Temporary teeth, when, number of. 10. Permanent teeth, classes and number; “wisdom teeth.” 11. Structure of teeth—pulp, dentine, enamel, cement, cavity, blood-vessels and nerves. 12. Arrangement of substances. 13. Variety of action of teeth; movements of jaw and effects.

CHAP. IV. — 1. Bones of trunk, classes and number. 2. Spinal column, original number of bones, fusing of bones. 3. Vertebrae, number, how united, form what, uppermost bone, lower extremity where. 4. Regions of the spinal column; interlocking. 5. Sacrum, what, where. 6. Coccyx, what, where; extension of. 7. Structure of a vertebra—arches, spines, attachments, ligaments, muscles. 8. Vertebral cartilages—blows and jars; hardening in age. 9. Spinal canal. 10. Curves of backbone; force of shock divided; increase cavity, afford support. 11. Nerve and blood-vessel channels. 12. Turning of the head; axis, atlas, odontoid peg. 13. Ribs, number, joints, true ribs, false ribs, floating ribs; length and direction; capacity of chest increased and diminished. 14. Chest, how formed; protection; muscles of walls. 15. Sternum, form, structure, attachments, bones in originally. 16. Arches of chest, form of. 17. Hyoid bone, form, attachments. 18. Upper extremities defined; number of bones of; divisions of. 19. Shoulder bones, clavicle, scapula; structure of shoulder-joint; dislocation of. 20. The arm, humerus. 21. Forearm; ulna and radius at elbow and wrist; rotary motion of hand. 22. Structure of wrist; variety of movement of hand. 23. Bones of hand, number, classes; the hand as an instrument. 24. Superiority of right hand; right and left side compared; unequal motion; exercise, etc., of left extremities.

CHAP. V. — 1. Lower extremities defined; joined to what. 2. Divisions of lower extremity; number of bones in. 3. Hip-bone, structure, socket; pelvis. 4. Femur, structure of—ball, cartilages; atmospheric pressure on joint; ligaments of hip-joint and offices. 5. Motion of hip-joint, depth of socket; twistings and dislocation. 6. Bones of leg—tibia, fibula, patella—entering into formation of knee, ankle. 7. Knee-joint structure; ligaments; patella and its function. 8. Ankle, number of bones, structure of, movements; liable to injury. 9. Foot, number of bones; instep; toes; compared with hand as to functions. 10. Joint defined; general classes of; classes of movable. 11. Ball-and-socket—examples of. 12. Hinge—motion, examples

of. 13. Pivot—motion, examples of. 14. Mixed joints. 15. Sliding joints, characteristics. 16. Immovable joints, structure of, examples of—sutures. 17. Cartilages of joints; synovial membrane and fluid—functions of. 18. Ligaments described; tendons; disposition of ligaments about joints. 19. Wonderful joint apparatus. 20. Coverings of the skeleton,—muscles, skin, hair, etc. 21. Health of bone—balance in processes; primary requisites. 22. Proportions of constituents; preponderance of either constituents and effects; unimpaired digestion necessary; circulation normal; exercise to stimulate and strengthen. 23. Distortion from improper posture. 24. Lateral curvature of spine; weakening of spinal muscles; permanent contraction; shortening of a leg. 25. Importance of balanced position; correction of curvature. 26. Distortion from dress; false notions; displacement of internal organs. 27. Impeded respiration and circulation. 28. Bone liable to disease. 29. Inflammation of periosteum, causes; felon, treatment of. 30. Ulceration and effects of; scraping of the bone. 31. Death of bone; natural removal of; removal by surgery. 32. Softening of the bones; “bow-legs;” rickets; deficiencies to be supplied; mechanical appliances. 33. Sprains—nature and treatment of. 34. Dislocations—indications; reduction. 35. Fractures—production, indications, treatment, process of healing, caution in use. 36. “Bolting” of food; health of teeth important. 37. Particles of food lodged in teeth, removal of; brushing and brush; dentifrice; tender gums; dentist’s services; artificial teeth.



EXPLANATION.

1, *Extensors* of the fore-arm, wrist, hand, etc. 2, *flexors* of the wrist, hand, etc. 3, *biceps*, bends the fore-arm upon the arm, etc. 4, *deltoid*, raises the arm and moves it forward and backward. 5, *triceps*, extends the fore-arm, etc. 6, *pectoralis major*, draws the arm to the side and across the chest. 7, *serratus magnus*, raises the ribs in inspiration. 8, *rectus abdominalis*, exert an equable pressure upon the abdominal organs, keep the abdominal walls tense, etc. 9, *pronators*, turn the fore-arm inwards. 10, *flexors*, bend the wrist, hand, etc. 11, *tensor femoris*, renders the connective tissue of the thigh tense and aids in moving the thigh outwards; 12, *sartorius* bends the leg upon the thigh and aids in crossing the legs; 13, group of *abductor* muscles. These draw the thighs outwards. 14, *rectus femoris*, one of the chief extensor muscles of the thigh. 15, *tibialis anticus*, bends the foot on the leg; 16, group of muscles which extend the toes. 17, *vastus externus*, aids in extending the leg.

Fig. 18. Front View of the Superficial Muscles.

THE MUSCULAR SYSTEM.

CHAPTER VI.

THE MUSCLES. — STRUCTURE, CLASSES, AND FUNCTIONS.

1. **Muscle.** — To produce motion in the animal machine one particular substance is employed, and is so situated and arranged as to perform very conveniently all the duties required of it. It is called *muscle*, and it constitutes all those portions of the body commonly called flesh, as distinguished from fat, bone, sinew, etc. It is the *red* or *lean* part of meat, and forms a very large portion of the bulk of the animal body.

2. Muscles are attached principally to the bones, and, possessing a high degree of contractility, they move the various parts of the body in the direction desired by the will. At least, this is the function of a great class of muscles called the *voluntary* muscles; but there is also a class called *involuntary*, which act independently of the will, as those regulating the action of the heart and of the respiratory organs, etc.

3. **Structure of the Muscles.** — The muscles generally lie just beneath the skin, and surround the bones. They serve to give much of that graceful contour which the body exhibits.

4. The muscles individually consist of bundles of fibres placed parallel to each other and bound up in a thin, strong casing; and these fibres are, in turn, composed of smaller bundles, or *fasciculi* (Lat. *fasciculus*, a little bundle). These fasciculi are themselves composed of

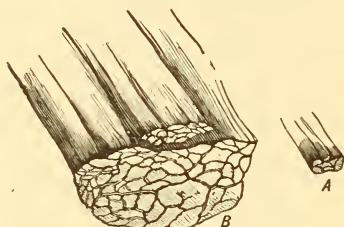


Fig. 19. A small portion of muscle, consisting of larger and smaller Fasciculi.

EXPLANATION.

A, natural size; B, magnified five diameters.

fibres enclosed by a delicate, structureless membrane, called the *sarcolemma* (Gr. *sarx*, flesh; and *lemma*, a husk). It is the contractions of the separate fibres, all acting at the same instant, that give to the muscle its great strength. Each muscle is distinct from

every other, being enclosed in its own sheath, and easily separable from other parts.

5. When we consider that there are more than four hundred muscles in the human body, each named and each subserving some necessary purpose, we can realize how extensive a subject is anatomy, and how much application is required to obtain a knowledge of its details.

6. Size, Shape, and Attachments. — Antagonists. — The muscles vary greatly in size, shape, and method of attachment to the bones and other parts. Some are long and thin, others broad and flat, some circular, and still others serrated or tooth-shaped. They are arranged in pairs, and, with few exceptions, each muscle has an *antagonist*, by the contraction of which motion in an opposite direction is produced. Thus as one muscle or set of muscles bends a limb, the opposite muscle or set extends or straightens

it; and hence the former are called *flexors*, the latter *extensors*.

7. For purposes of description each long muscle may be regarded as consisting of three parts, viz., the *body*, which is the middle portion, full and round, and the two *extremities*, which taper gradually and gracefully. The voluntary muscles are connected with the bones generally, but some are attached to cartilages, to the skin, and to other structures. Involuntary muscles are not generally attached to the bones, but form part of the walls of internal organs, as in the heart, blood-vessels, stomach, and intestines.

8. Muscles are attached to bones sometimes directly, but more commonly by means of *tendons* or sinews, which are strong, glistening bands or cords of fibrous tissue, continuous with the muscle at its point of attachment with the bone. The tendons sometimes extend a considerable distance to parts remote from the moving muscle, and run through grooves before becoming attached. In this way they act as pulleys, and give motion in a direction different from that they would if their course was direct, as in the superior oblique muscle of the eye, etc.

9. By a wise provision, in places where the tendons would play over hard surfaces, there are interposed little



Fig. 20. Biceps muscle of the arm.

EXPLANATION.

- a, body of the muscle.
- b, b, superior tendons.
- c, inferior tendons.

sacs, called *bursæ*, which contain fluid and act as cushions.

10. The end of a muscle attached to a bone or part which is stationary is called the *origin*, that to the movable bone or part the *insertion*, of the muscle.

11. **Tendons.**—The tendons, although very strong, are slender, and hence conduce greatly to the symmetry of parts that would otherwise be bulky and ungraceful. If the great muscles of the arm were prolonged to the wrist, or those of the leg to the ankle, the limbs would lack beauty of outline. These muscles terminate in long, slender tendons, which, commencing above the wrist or above the ankle, pass over these joints to the foot and toes, or hand and fingers, respectively. When the foot is stretched out, or when the wrist is not bent, the muscles and their tendons form nearly straight lines; but when either joint is bent, the tendons curve, as it were, around a pulley. When muscles act very powerfully, the tendons would be forced up from their places, in order to fall into straight line with the muscles, were they not bound down by strong bands, called *ligaments*, running across them. At the back of the calf of the leg certain muscles are connected with the heel by the *tendon of Achilles*, the largest and strongest in the body.¹

12. **Circular Muscles, etc.**—A form of muscle quite common is that of the ring or circle. Muscles of this form close or constrict natural openings of the body, as the mouth, eye, and those leading into and out of the stomach, etc. The most beautiful and delicate of all is the muscle which forms the *iris* of the eye. These ring-

¹ In Grecian fiction this tendon is represented to have been the only vulnerable part of the body of *Achilles*, and hence its name.

like muscles are technically named *annular, orbicular, or sphincter muscles*.

13. By means of the circular and other muscles of the face, the various expressions of the emotions are effected; and hence they constitute what are termed the *muscles of expression*.

14. Muscles are attached to the skin and move it over the tissues beneath it, as is seen in wrinkling the forehead or moving the scalp. In the lower animals this is more common, enabling them to give quick motion to the skin and thus rid themselves of troublesome insects.

15. **Contractility of Muscles.** — The property of contractility, under certain exciting causes, distinguishes muscles from other tissues of the body.

In contraction the fibres shorten, and the apparent gain in the bulk of the muscle is at the expense of its length. Under natural conditions this contraction is accomplished in obedience to the stimulus imparted by the nerves which supply the muscle. This is strictly true in regard to the muscles called *skeletal* muscles, those which move the limbs or other parts of the body and cause change of its position. These movements can be accomplished normally only when the nerves themselves remain in communication with the brain and spinal cord.

16. Another condition exists in muscle, however, which is termed its *irritability*. This may be exhibited by applying some stimulus to the muscle, as by pinching, or applying a hot iron to it, or by a current of electricity; contractions may be thus produced independently of the nerve. But the same results may also be attained by applying a stimulus to the nerve. It, also, is irritable; and although there is no change in form in the nerve, move-

ments are set up and communicated to the muscle, which contracts, as in the former case. These phenomena in the nerves are called *nervous impulses*.

17. It is now conceded by physiologists that muscular and nervous irritability are separate from each other, as shown by the fact that certain things that act as stimuli to the muscles will not so act upon the nerves, and *vice versa*.

18. **Velocity of Contraction.** — Elaborate instruments have been invented and are used to measure muscular movements, — the velocity of nervous impulse, etc. Some of the facts ascertained by these means are as follows, viz.:

a. That the commencement of molecular changes in a muscle stimulated to contraction by electricity occupies about $\frac{1}{100}$ of a second.

b. That the shortening of the fibres of the muscle occupies about $\frac{4}{100}$ of a second.

c. That the return of a muscle to its former length occupies about $\frac{5}{100}$ of a second.

19. **The Unstriated Muscles.** — This class of muscles differs from those we have been considering in that they consist of flattened bands made up of bundles of fibres; again, they have no surrounding membrane or sheath, and do not present under the microscope the appearance of strings of beads, and hence are called *unstriated*.

20. The *unstriated muscles* belong principally to the *viscera*, or internal organs. They are found also in the skin at the bases of the *papillæ*, and their contraction causes the appearance of the skin sometimes seen, and commonly called "goose skin."

21. While the general muscles of the frame are seen to be connected with and regulated by the nerves originating

from the brain and the spinal cord, those of the internal organs seem to be under the control of the *sympathetic* nervous system.

22. The phenomena of both classes of muscles are very similar as regards contractility, the same stimuli producing like results in each case. The wave-like impulse observable in a marked degree in the muscles of the intestines is called *peristaltic* motion.

23. The continued action of the muscles of the heart under the various stimuli peculiar to it will be studied later. Its rhythmic action is the result of various forces, the ultimate result of which is to produce regular and continued contractions and expansions.

24. **Arrangement of Fat.** — Fat ordinarily constitutes about $\frac{1}{10}$ part of the weight of the body. It is found under the skin, between the muscles and about the internal organs. Its various uses are to maintain bodily warmth, to fill up inequalities and thus give symmetry to the form, and to act as cushions to various muscles, joints, etc.

CHAPTER VII.

BRIEF DESCRIPTIONS OF IMPORTANT MUSCLES.

1. **ELABORATE** descriptions of the muscles are impossible and undesirable in a volume of this kind, and therefore brief mention is made of those of the several divisions of the body.

2. **Muscles of the Head and Face.** — The muscles of the head

and face, by their varied motions and degrees of development, give different expression to each individual, and make it impossible for any two persons to look exactly alike.



Fig. 21.

EXPLANATION.

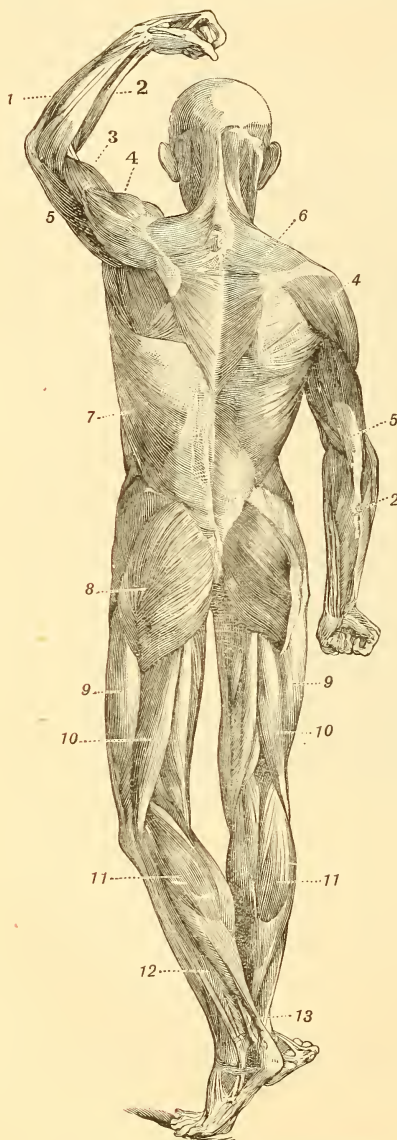
A closes the eye; *B* raises the eyebrows, and wrinkles the forehead; *C* raises the lower jaw; *D* closes the lips; *E* compresses the wings of the nose; *F* draws the corner of the mouth downward. Each muscle has a name given to it because of the work it performs, its shape or size.

3. One large muscle, which covers the entire front and top of the skull, moves the scalp and throws the skin of the forehead into transverse wrinkles, while two small

muscles, just above the inner angles of the eyes, draw the eyebrows downward and inward, and produce vertical wrinkles in the forehead. One circular muscle forms the eyelid and closes it to protect the eye; another muscle raises the upper lid, and six muscles are employed in giving the ball of the eye its various motions. A ring-like muscle surrounds the mouth and closes the lips tightly, as in puckering the lips to whistle. Other small muscles raise the upper lip, draw the angles of the mouth upward and downward, depress the lower lip, elevate the sides of the nose, move the lower jaw (powerful muscles in this instance), and produce the several movements of the face, the rapid changes which are called *facial expression*.

4. Muscles of the Neck. — The muscles of the neck are numerous and complicated. Those in front are rendered more complicated by the position of the bone near the root of the tongue (the *hyoid* bone), to which several of them are attached. These muscles extend upward to the head, but some of them attach themselves to the hyoid bone, while smaller muscles extend from that bone upward. The muscles of the front of the neck bend the head forward, draw the lower jaw down and thus open the mouth, aid in moving the organs of speech, and assist in swallowing. The muscles of the sides of the neck bend the head to the side when those on one side act alone, and rotate the head on the spine. When those of both sides act together, they aid in keeping the head erect. The muscles in the back of the neck draw the head backward, raise the shoulders, and also aid in holding the head erect.

5. Muscles of the Trunk. — The muscles of the trunk are those that cover the front, sides, and back of the *thorax*



or chest, and those that form the walls of the abdomen. There are also some internal muscles that properly belong to the trunk.

6. The *muscles of the breast* cover the upper and front part of the

EXPLANATION.

1, *extensors* of the hand; 2, *flexors* of the hand, wrist, and fingers; 3, *biceps*, bends the fore-arm; 4, *deltoid*, raises the arm and moves it backwards and 2 forwards; 5, *triceps*, extends the fore-arm; 6, *trapezius*, moves the head backward, sideways, etc., and raises the shoulder; 7, *latissimus dorsi*, assist in respiration, aid in lowering the arm when raised, etc.; 8, *gluteus maximus*, raises the thigh backward and outward; 9, *vastus externus*, aids in extending the leg; 10, *biceps cruris*, aids in bending the leg on the thigh; 11, *gastrocnemius*, forms the calf of the leg, and aids in extending the foot; 12, *flexors*, of the foot; 13, *tendo Achilles*, attached to the heel and to 11.

chest. The *pectoralis major* or great muscle of the breast has an extensive attachment to the ribs, breast-bone, and collar-bone, and is also attached to the upper part of the *humerus* or arm-bone. It draws the

Fig. 22. Back View of the Superficial Muscles.

arm forward, across the body, toward the opposite side; and when it acts with the great muscle of the back, the arm is drawn close to the side. The muscles on the sides aid in moving the ribs during breathing.

7. The muscles of the back are very numerous from the fact that many and varied movements are required at this point. They all arise from the bones of the spinal column, and aid in keeping the trunk in the erect position. Some of them give the backward motions to the head, and others draw the shoulder-blades back towards the spine. The *latissimus dorsi* or largest muscle of the back is inserted into the *humerus* or arm-bone near the point where the great muscle of the breast is also inserted. When it acts alone, it draws the arm backward; but when it acts with the breast muscle, it helps to draw the arm close to the side.

8. The *abdominal muscles* form the movable walls of the abdomen; acting together, they bend the trunk forward, and they also aid in the movements of breathing. At the lower part of these muscles, just above the long rim of the pelvis, are two weak points in the abdominal walls, and they often give way and allow a portion of the intestines to come through, thus constituting what is called *hernia* or rupture.

9. The spaces between the ribs are filled by muscles which raise the ribs in order to make room for the inflation of the lungs in breathing. These are called *intercostal muscles* (Lat. *inter*, between; and *costa*, a rib).

10. The *diaphragm* (Gr. *phragma*, fence) is the broad, convex-concave muscle, situated in the interior of the trunk, which separates the cavity of the thorax or chest from that of the abdomen. It rises and falls during breathing, in which it plays an important part.

11. Other muscles are situated in the cavity formed by the bones of the hips, and pass outward and are inserted into the upper part of the *femur* or thigh-bone. They assist in rotating the whole leg so as to turn the toes outward, and in drawing the thigh upward in the direction of the abdomen.

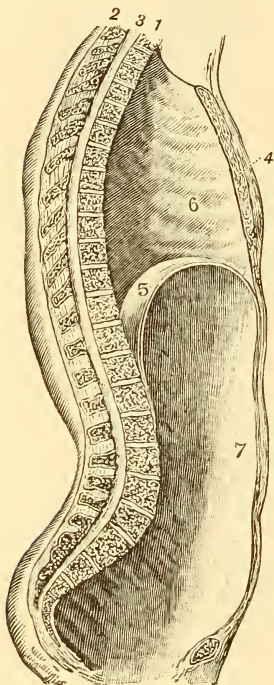


Fig. 23. The Cavities of the Trunk.

EXPLANATION.

1, bodies of the vertebræ; 2, spinous processes of the vertebræ; 3, spinal canal; 4, breast-bone; 5, diaphragm; 6, thorax; 7, abdomen.

12. **Muscles of the Upper Extremities.**—The muscles surrounding the shoulder, together with others from the trunk, previously described, are attached to the arm (or upper-arm, as it is sometimes called) and constitute its motors. The triangular muscle called the *deltoid* (from its resemblance in form to the Greek letter *delta*), situated at the top of the shoulder, raises the arm to the side of the head, while smaller muscles acting with the great muscles of the breast and the back draw it down to the side of the body. Other movements of the arm caused by these great muscles have been stated previously.

13. Three muscles occupy the front part of the arm. The chief one of these is called the *biceps muscle* (Lat. *bi*, two; and *caput*, a head), because at its upper extremity it has two heads with separate tendons. These muscles draw up the fore-

arm as in the attitude of striking, while the large muscle on the back of the arm, called the *triceps* or three-

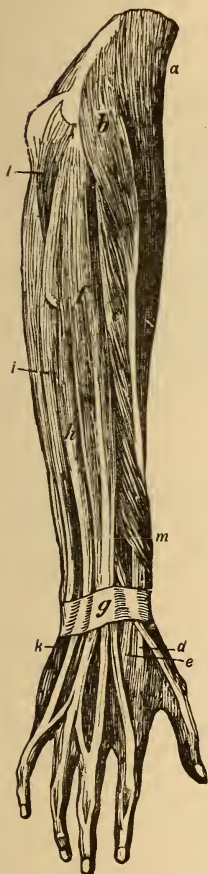


Fig. 24.

EXPLANATION.

f, the muscle that straightens the fingers.

h, the muscle that straightens the little finger.

i, the muscle that assists in straightening the wrist.

l, the muscle that assists in extending the fore-arm.

d, the muscle to extend the second bone of the thumb outward.

e, the muscle to extend the fore-finger.

h, the muscle to draw the little finger outward.

m, the muscle to roll or turn the fore-arm, and turn the hand.

g, the ligament which binds down the muscles at the wrist.



Fig. 25.

EXPLANATION.

a, the muscle to turn the hand inward.

b, the muscle to bend the wrist.

c, *d*, the muscles to bend the hand.

e, the muscle to assist in bending the hand.

g, the muscle to bend the thumb.

headed muscle, extends or straightens the arm upon the forearm, thus acting as an *antagonist*.

14. The muscles on the front of the forearm bend the whole hand forward at the wrist, and also bend the fingers so as to form the clenched hand or fist. The action of these is antagonized by the muscles of the back of the forearm, which straighten the wrist and fingers, and also carry the whole hand backward at the wrist. A set of muscles on the thumb side of the forearm draw the hand toward that side, and also rotate it outward so that it rests on its back, the palm turned upward. Another set, situated on the side corresponding with the little finger, draw the hand toward that side, and rotate it inward, so that the palm is turned downward. When the hand rests on its back, it is said to be supine, and the muscles giving the motion are called *supinators*; those that turn the palm downward are called *pronators*, and the hand is then spoken of as being in the prone position.

15. **Muscles of the Lower Extremities.** — The muscles which move the thigh are short, thick, and powerful. They form the fleshy mass that covers the back of the hip-bones, and arise from the bones of the pelvis and lower part of the backbone.

16. The four large and long muscles situated in front of the *femur* or thigh-bone straighten the leg upon the thigh after the knee has been bent. They arise from the pelvis and thigh-bone, and unite below in a broad tendon in the centre of which the *patella* or knee-cap is situated. Below the knee-cap this tendon contracts, and is called the *ligament of the patella*, and is attached to the upper part of the *tibia* or shin-bone. A large biceps muscle back of the thigh-bone draws the leg up backward, so as to bend the knee; and a set of muscles on the inner sides of the thighs draw the legs together.

17. On the front of the leg are several muscles called *extensors*, the tendons of which extend to the ankle and to the bones of the toes. These straighten the toes and draw the foot up in front toward the leg. The muscles

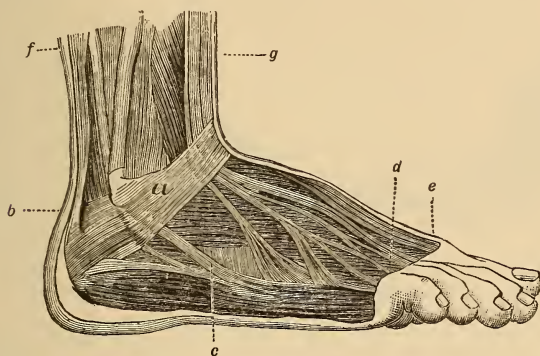


Fig. 26.

EXPLANATION.

In this figure the muscles of the lower part of the leg and of the foot are represented. Those used in extending the toes, and bending the foot upward, are situated in front of the leg and upper part of the foot; while those that bend the foot downward, and bend the toes, are located at the back of the leg and on the sole of the foot. These muscles are attached to the toes by round, cord-like tendons, that may be plainly felt, and their form seen, when the toes are extended or drawn upward.

a, the broad ligament that binds down the muscles of the ankle.

b, the tendon of Achilles, at the back of the ankle, which extends from the muscle of the calf to the back of the heel. This is the strongest tendon of the body: it raises the heel.

c, muscles which turn the foot outward.

d, tendons of muscles that extend the toes.

e, tendon of muscle that extends the great toe, and separates it from the next.

f, muscle of the calf of the leg.

g, muscles that bend the ankle, and pull the foot toward the shin.

on the back of the leg, the tendons of which also extend to the ankle and foot, flex or bend the foot and toes, and draw up the heel so that the toes are pointed downwards. These latter muscles are called *flexors*. A similar arrangement of extensor and flexor muscles and their tendons exists in the forearm and hand, as we have seen.

18. Muscles attached to Levers.— The great majority of the muscles in the body are attached to distinct levers formed by the bones. It is one or other of the extremities

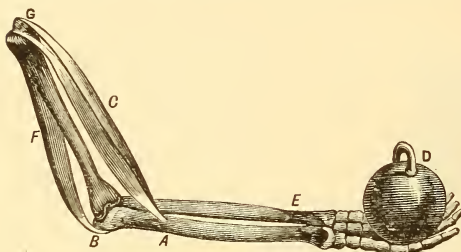


Fig. 27.

The Bones of the Upper Extremity and the Biceps and Triceps Muscles.

EXPLANATION.

In this figure the biceps muscle is shown at C, and the two tendons which attach it to the shoulder are seen at G, the point of origin.

The attachment of the muscle to the radius is shown at A, the point of insertion.

The triceps muscle is represented at F, and the tendon by which it is attached to the radius is shown at B. These two muscles are *antagonistic* muscles.

of a bone which plays the part of a *fulcrum* when the bone is in use as a lever, the muscle being the *power*, and the resistance to be overcome the *weight*.

CHAPTER VIII.

PHYSIOLOGY AND HYGIENE OF MUSCULAR EXERCISE.

1. Object of Exercise.— We shall here speak of proper muscular exercise as being one of the chief agents in the maintenance of health, and in its restoration when impaired. Primarily, exercise gives health, strength, and tone to the muscular system; and secondarily, by means of its effect on the muscles it confers health upon all the other tissues. Grace and dexterity of movement are the desirable subordinate qualities to be attained.

2. Influence of Exercise. — We have learned that the muscles are called into action by nervous impulse; and it should be remembered that in exercise “not only the muscle, but almost the whole nervous system labors,” and that in muscular exercise there is just as truly a putting forth of nervous energy as there is in mental efforts.

It is next desirable to get clear ideas of the influence of exercise, and to learn how it can do good. The blood-vessels permeate the muscles which they supply with blood, and are covered and protected by adjacent overlapping muscles. In consequence of their location, the blood-vessels are compressed and their contents propelled by the contraction and pressure of the muscles. But the increased activity of the circulation thus induced by muscular action is not confined to the muscles. The action of the heart is hastened, the blood passes through the lungs more rapidly and in larger quantities, and the respiratory and perspiratory organs are urged to quickened action, in order to purify the blood with sufficient rapidity. The influence of increased circulation is felt in all the organs. Increased activity occasions combustion of material and the elimination of waste products; and hence, to supply the demand for quantity of blood, the appetite is excited, more food is eaten, and the digestive organs participate in the general activity. It will thus be seen that exercise is a renovator of the body, that almost every function is impelled to increased activity by it, and that the whole system receives a healthful impulse. In short, muscular exercise influences so greatly the two vital processes — destruction and renewal of tissues — that it must be taken into chief consideration by him who would have good health and long life.

3. To the young, exercise is especially important, since it not only stimulates the functions to which allusion has been made, but also contributes to development and largely determines the size, strength, and functions of the whole body.

4. **Muscular Strength.**—Difference in physical strength is due mainly to the non-employment of the muscular system, in one case, and to its regular and continued exercise in the other. Many who lead active and laborious lives have vigorous health, and muscles that will endure an almost incredible amount of labor; others, equally strong in early age, who lead sedentary and inactive pursuits, are subject to a variety of ailments and have but little muscular strength.

5. By a regular and moderate exercise of individual muscles they will increase both in size and strength. When kept in action more blood is sent to them, and consequently a greater deposition of muscle-making substance takes place. On the other hand, if muscles are unused, atrophy or waste takes place, and they become weak and flabby.

6. **Amount of Exercise.**—To increase the size and strength of a muscle, its exercise must be uniform and not excessive. The amount of exercise must be determined by the present strength of the individual, and it should be discontinued at the first sign of fatigue. The intervals of relaxation should be frequent in order to give the muscle and its nerve opportunity to recruit their powers. If the occurrence of fatigue is not regarded and the muscles are still continued in action, their energies may become so much exhausted as to permanently impair their contractile power.

7. Proper and Improper Exercise. — Whatever the kind of exercise, there are certain rules which every young person should be taught to regard. In youth, bones, muscles, and nerves are immature; they gradually attain their bulk, firmness, and approximate perfection. They require gentle treatment. Violent exercise is quite out of place at this period of life, and what should be aimed at is slow exercise with frequent intervals of rest. The object of exercise in the gymnasium or elsewhere should not, primarily, be to attain dexterity, though this naturally follows after a time, but to train and develop the muscles. Violent exertions, in the attempt to accomplish difficult or rapid feats, produce exhaustion and greatly overstrain the muscles. Whether a particular gymnastic feat is accomplished or not is a matter of but little consequence; the important matter is that the muscles shall have sufficient exercise and shall not be overstrained. Muscular exercise is potent for evil as well as for good, and when excessive is certainly injurious. It should begin moderately and be *gradually* increased.

8. Preternatural Muscular Development. — Increase of the bulk of the muscles means also increase in the quantity of blood and of the space to be travelled by it. Such increase of blood and territory demands augmentation of power to drive the vital fluid through the system, and to get rid of the gases of the blood. Only to a limited extent can the heart accommodate these increased demands, and there is no reason to believe that the aerating surface of the lungs can be largely increased. But a preternatural development of muscle requires a preternatural amount of work of the heart and lungs. It is well known that a large proportion of professional athletes die early of

lung and heart diseases; and one of the reasons why men whose muscular systems have been preternaturally developed so often die of lung and heart diseases is to be found in the fact that these organs are, in such people, habitually overworked in supplying the over-developed muscles.

9. It is very important to remember that an over-development of the muscles is possible, and that there is danger in a system of training in which the muscles are so cultivated as to be especially able for great, sudden efforts. Great momentary muscular strength and great endurance under continued exertion are by no means synonymous. They may be united in the same person, but it is possible to possess the former and not the latter. It is equally important to remember that moderate, regular, protracted muscular work is the best cultivator of endurance, and that endurance is to be chiefly sought in cultivating the muscles.

10. **Pure Air and Sunlight for Exercise.** — It has already been stated that exercise stimulates the circulation of the blood and that the quantity of that fluid passing through the lungs and demanding aeration is greatly increased under its influence. The air breathed, at that time especially, should contain its proper proportion of oxygen, and hence exercise should be conducted in the open air or in freely ventilated rooms. Under the most favorable conditions, the hastened respiration indicates the demand for oxygen in increased quantities. If the air breathed is impure

¹ Even the training undergone for the performance of great physical feats exhausts life force in the long run. Athletic sports pushed to extreme produce bad results, and they must be so pushed to win renown. Dissipation has nothing to do with many instances of lives thus shortened. In either case the penalty is exacted.

from a mixture of unwholesome gases, "or if its proper proportion of oxygen be reduced by having been previously breathed, the good effect of exercise on the vital force is lost, and even a positive injury may be the result." Winship, the famous athlete, when in his best condition often fainted in a close room. Under the most favorable circumstances his heart and lungs had as much as they could do to meet the needs of his system, so that when compelled to work in vitiated air they were unable to meet the requirements.

11. Sunlight exerts a marked influence upon both vegetable and animal life. The plant hidden from the light loses its color and vigor, and animals deprived of it also have feebler vitality. The results of repeated experiments would appear to prove conclusively that labor can be borne with less fatigue in the sunshine than in the shade, the temperature of the air being the same in both instances. Pure air, sunlight, and well-regulated exercise are the hand-maidens of health.

12. **Modes of Exercise.**—That form of exercise is best which brings into moderate play the greatest possible number of muscles, and hence the exercise of one set of muscles should not be allowed to exclude others. Gymnasias are equipped with apparatus adapted to this end; but where such means are not available, much can be accomplished by using the simple means within reach. Those employed in sedentary pursuits should regularly devote some time each day to an amount of exercise within the limits of prudence, the amount to be determined by the strength of the individual, and, as said before, the exercise should be discontinued at the first sign of fatigue.

13. *Running* is an excellent exercise, bringing muscles into play more vigorously than walking does; but there is probably no other form of exercise that requires such cautious, gradual training. In practising running, we should bear in mind the fact that in all strong, athletic exercises we should be satisfied with gradually attained powers. Both lungs and heart are sometimes injured by the strain put upon them by undue exercise in running. Breathlessness, strong beating of the heart, and soreness of muscle lasting after exercise, show that it has been too prolonged, or too rapid.

14. *Walking* is, in many respects, a good exercise. In walking, the muscles chiefly exercised are those of the legs; but those of the arms and trunk participate to a certain extent, and the exercise which the latter obtain increases the breathing power of the lungs. The respiration is quickened, a greatly increased amount of air is inhaled, and a correspondingly large quantity of carbonic acid exhaled. This, while true of various modes of exercise, is especially beneficial in walking in the open air. Investigations show that the quantity of air inspired by a person when walking at the rate of six miles per hour is seven times the quantity inspired by the same individual when quiescent, or in a recumbent position. But walking does not sufficiently exercise the muscles of the upper portions of the body, and hence is not to be depended on for all purposes of exercise.

15. *Swimming* brings into action almost all of the muscles of the trunk and limbs, and is therefore an excellent mode of exercise. The effects of bathing will be presented in another chapter.

16. *Rowing* also is an excellent exercise, bringing into

play principally the muscles of the shoulders, arms, and loins. When much practised, rowing may cause a tendency to round shoulders and hollow chests unless care is taken to bring the trunk to an erect position. Here, again, due regard should be given the rule that the exercise of one set of muscles must not be allowed to exclude others, and hence rowing should not have "the lion's share" among the forms of exercise.

17. *Calisthenics* is a term formed from two Greek words, — *kalos*, graceful, and *sthenos*, strength, — and, as now used, signifies the exercise of the body for the promotion of strength and grace of movement. In this sense it may be made to include all exercises with Indian clubs, dumb-bells, etc. One of the most important things to be remembered in all exercise is, that it is the motion more than the weight of implements that yields benefit; so that in the beginning, at least, light dumb-bells, etc., should be employed. Calisthenics or light gymnastics may be so varied as to call into play all the voluntary muscles.

18. *Fencing, tennis, riding, driving, "wheeling"* in its various forms, are exercises which include sociability and enjoyment, and therefore have a great advantage over those of a grave and solitary nature. All outdoor exercises except the roughest and most dangerous are to be highly recommended, as they combine all the useful accompaniments of fresh air, high spirits, and physical effort. In fact, there is nothing that comes nearer than judicious exercise to being a real "cure all."

19. **Artificial Props. — Tight Clothing.** We have referred to the muscles attached to the spine and employed in keeping the trunk erect. The course already alluded to as

the proper one for increasing the power of muscles applies to these, and is especially necessary to them. Nature is continually endeavoring to exercise economy, and when organs are not employed in fulfilling the purposes for which they were intended, she curtails to the utmost her supplies of nutriment. "Thus it is that the unused brain becomes dull and stupid, and the ligated artery is absorbed;" and thus it is, also, that the unused muscle dwindles from inaction and consequent lack of nutrition, and becomes totally unprepared for any extra demands which may be made upon it.

20. By a large proportion of the female sex, and by many of the other, these natural laws are neglected or repudiated. Not only are the muscles of the spine not educated as they should be, but by many are not allowed to perform the work nature designed. By the strong constriction of tight clothing and tight lacing it is attempted to keep the spine erect with but little aid of the muscles; and thus a severe restraint is put upon them by a forcible compression which interferes with their contraction and also impedes the circulation of the blood in them. Enforced inaction and deficient circulation dwarf and weaken the muscles, and they become unable to perform their natural and rightful function of keeping the spine erect and chest expanded. To restore the strength of such deteriorated muscles constriction and artificial props must be removed, and the muscles allowed unconstrained exercise, their natural function.

The muscles of the back are adequate to keep the spine erect and the shoulders in proper position, if their strength is cultivated by proper means in early age. Habits of

walking and sitting erect should be inculcated, but not on any occasion to an extent that causes fatigue.

21. "Girls and young women," remarks an eminent physician, "ought to be physically trained as carefully as are boys and young men; while nature has not designed that the sexes shall be possessed of equal strength, the female should have strong muscles, lung space, and all the benefits to be derived from proper bodily exercise. In some schools this matter is receiving enlightened attention," etc. But it is absurd to require or expect a free exercise of the body, encased in tightly fitting, muscle-constricting clothing; the whole body must be free to expand and bend; otherwise the exertion soon becomes painful and worse than useless. Besides, as has been well said, "The processes of life conducted by the vital organs of the body are too essential for us to trespass upon them by any of those external appliances which tend to compress them or interfere with natural freedom of motion."

22. **Alcohol, Tobacco, and the Muscles.** — The injurious effects of alcoholic drink and tobacco on digestion, the blood and its circulation, and on the nervous system are fully stated elsewhere. As the health of the muscles is intimately related to these, it is therefore inevitable that they must participate in and be impaired by influences which are so deleterious to digestion, blood-making, and circulation, and nervous health. Alcohol paralyzes nerve-force, and thus robs muscle of its natural stimulus; it frequently causes fatty degeneration, not only of voluntary muscles, but those of the heart and arteries, thus changing the lean muscle into fat and destroying its structure. Tobacco attacks the nerves and causes unsteadiness of

nerve and muscular action. Muscle becomes exhausted sooner when alcoholic drink has been taken, and athletes avoid it when preparing for feats of strength or endurance. Human experience proves that alcohol and tobacco are enemies of the muscles.

Suggested Points for Questions.

CHAPTER VI. — 1. The production of motion — muscle. 2. Attachments and contractility; voluntary and involuntary. 3. Location, bodily contour. 4. Fibres, fasciculi, sheath, simultaneous contraction of fibres. 5. Number of muscles. 6. Size, shape, antagonists, flexors, and extensors. 7. Three parts of a long muscle; attachments of voluntary and of involuntary. 8. Method of attachment to bones — tendons, pulleys. 9. Bursæ. 10. Point of origin and insertion. 11. Tendons, form, symmetry, functions; ligaments — uses. 12. Circular muscles, offices and examples of. 13. Muscles of expression. 14. Muscles of the skin. 15. Muscular contractility, how accomplished. 16. Muscular irritability; stimulus applied to nerve. 17. Nervous and muscular irritability distinct. 18. Velocity of contraction — commencement, shortening, return. 19. Unstriated muscles — absence of sheath, etc. 20. Muscles of *viscera*, etc., unstriated. 21. Muscles regulated and controlled by nerves — sympathetic nerves and internal muscles. 22. Similar phenomena of both classes; peristaltic motion. 23. Continued action of heart-rhythmic action. 24. Arrangement of fat — offices of fat.

CHAP. VII. — 1. Elaborate descriptions undesirable. 2. Muscles of head and face — expression; no two exactly alike. 3. Principal muscles of head and face and their functions — facial expression. 4. Muscles of the neck; attachments to hyoid bone; offices of the principal ones — front, sides, and back of neck. 5. Muscles of trunk, cover what, etc. 6. Muscles of breast — *pectoralis major*, location and functions; muscles of the sides — functions. 7. Muscles of back — number, origination, principal functions; *latissimus dorsi*, structure and office. 8. Abdominal muscles — functions; weak points of abdomen — *hernia*. 9. Intercostal muscles — functions. 10. Diaphragm — location, form, office. 11. Muscles of hip-cavity — functions, rotation of leg, etc. 12. Muscles of upper extremities — shoulder and arm; *deltoid* and

its office; smaller muscles of breast and back co-operate. 13. Three muscles of arm, functions; *biceps*, *triceps* — antagonists. 14. Office of front forearm muscles; of back of forearm; of thumb-side; of little-finger side; supinators, pronators. 15. Muscles of lower extremities — of the thigh and hips, origination in pelvis and spine — nature of. 16. Muscles of front of thigh-bone — offices; tendon of the patella, ligament and attachment; biceps of back of the thigh — function; muscles of inner sides of thigh — functions. 17. Muscles of front of leg — extensors — functions, tendons, attachments; of the back of the leg, ditto. 18. Muscles attached to levers — fulcrum, power, weight.

CHAP. VIII. — 1. Muscular exercise a chief agent of health; primarily and secondarily considered; grace and dexterity. 2. Influence of exercise — nervous impulse and labor; blood-vessels compressed and blood propelled by contraction; action of heart hastened; circulation quickened in lungs, etc.; increased combustion and elimination; increased appetite and digestion; exercise a renovator; healthful impulse; influences two vital processes. 3. Exercise important to the young — development. 4. Muscular strength — difference due to what; activity and labor; sedentary and inactive — contrast. 5. Regular and moderate exercise — effect; atrophy or waste — inactivity. 6. Amount of exercise — uniform and not excessive; amount determined by present strength; intervals; occurrence of fatigue to be regarded; exhaustion. 7. Rules for exercise; gentle treatment of immature muscles, etc.; violent exercise; primary object of exercise — dexterity or development; sufficient but not over-straining; moderation. 8. Over-development of muscle and its effects; increased demand on heart and lungs; athletes and length of life — reasons. 9. Danger of over-development; strength and endurance; cultivation of endurance chiefly important. 10. Pure air, sunlight for exercise — reasons; increased demand for oxygen; Winship. 11. Sunlight — influence of, on plants and animals; labor in sunshine and shade; the hand-maids of health. 12. Modes of exercise, characteristics of each; benefits to be derived; best form of exercise — greatest possible number of muscles. 13. Running. 14. Walking. 15. Swimming. 16. Rowing. 17. Calisthenics. 18. Fencing, tennis, riding, driving, “wheeling.” 19. Tight clothing — constriction interferes with exercise and development. 20. Natural laws neglected — muscles not educated but hampered; attempt to keep spine erect by tight lacing — effect on the muscles; removal of props; muscle adequate to keep spine erect, etc.; habits of walking, sitting, etc. 21. Physical training of girls and young women — strong muscles, lung space; no free exercise in tight clothing of trunk and limbs; trespass upon the vital processes by compression. 22. Alcohol, tobacco, and the muscles.

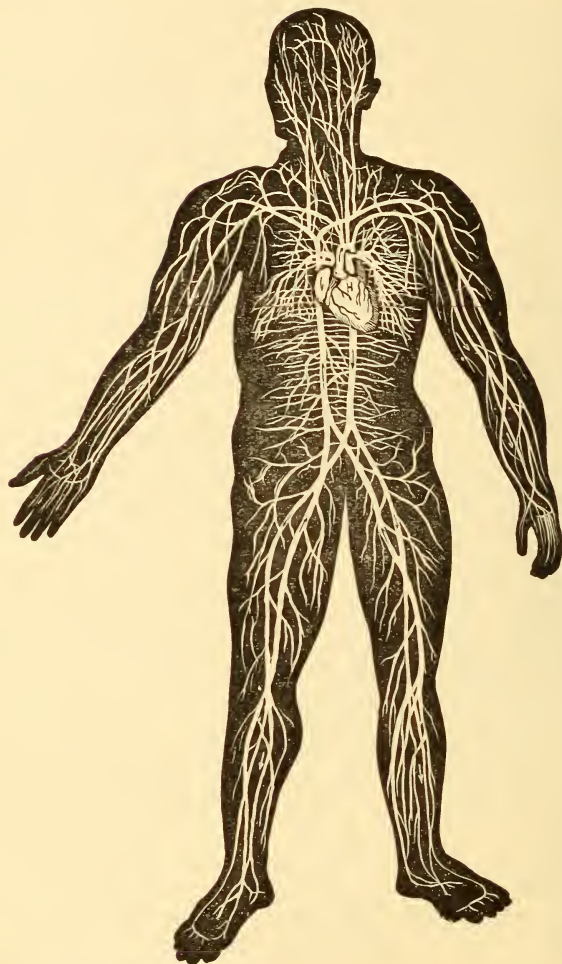


Fig. 28. General view of the Circulatory System, showing the arrangement of the heart and the larger blood vessels.

EXPLANATION.

H, the heart. The arrows indicate the direction of the circulation.

THE BLOOD AND ITS CIRCULATION.

CHAPTER IX.

THE BLOOD ; ITS COMPOSITION, PROPERTIES, ETC.

1. **The Vital Fluid.** — When the surface of the skin is pricked, even slightly, immediately a minute drop of red fluid is seen, proving that even up to the very limiting bound of the body the sea of life flows a never-ceasing tide, laving, irrigating, and nourishing every tissue.

2. This fluid, the *blood*, as it exists normally in the body, consists of the *plasma*,¹ an almost colorless fluid, holding in suspension the red and the white *corpuscles*, which are cellular bodies, differing in size and constituents.

3. The *red corpuscles* are the carriers of oxygen from the lungs, obtained from the air we breathe, to the various tissues of the body. The *white corpuscles* are *protoplasm* of a cellular form, not especially functional, — that is, not set apart for any particular process that we are yet aware of, — yet necessary to the performance of the functions of the blood as a whole.

¹ The *plasma*, or *liquor sanguinis*, is alkaline, transparent, and composed of water, fatty and albuminous matters, salts, and crystallizable substances of organic origin, and it forms about three-fifths of the volume of the blood.

The blood is also the carrier of the nutritive elements of food to the tissues which it permeates, and it takes away, by means of the veins, the waste or refuse material from the tissues.

4. As in the outside world there is a constant interchange of material necessary to the continuance of life — the exhalation from the ocean of vapor which, as rain, again descends and nourishes the vegetable world ; the fall and decay of the leaf, which enriches the soil for the reproduction of its kind ; the currents of water, at various temperatures, which interchange and regulate the climates of the world — so in the microcosm of a human being there are interchanges constantly going on ; the reception of material from without, which is built into the economy, being carried to it by the blood, and the rejection and throwing off, by means of the various organs of excretion, of matter which cannot be incorporated.

5. The blood, then, cannot be a fluid of unvarying composition. The amount and kind of food, the time of day, the degree to which the body has been exercised, — all these conditions change the amount and kind of its constituents. The color of the blood as it courses through the arteries is red, but when loaded with the impurities of the system, as seen in the veins, it is purple.

6. **Properties of Blood. — Coagulability.** — In a short time after being drawn from the body, blood becomes viscid, or jelly-like ; that is, it has become coagulated. If in a deep vessel, it forms a complete mould when removed. If blood thus coagulated be allowed to remain in a glass vessel for a longer period, it may be seen that a colorless fluid exudes from the surface and forms a layer ; and later on a layer of this colorless fluid will be found on the sides

and at the bottom of the vessel. This is called the *serum*,¹ and in it the clot floats, shrunken in size. The clot consists of *fibrin*, enclosing in its meshes the corpuscles of the blood. The *fibrin* is composed of fine fibres, called *fibrils*. Hence, in coagulating, the blood is separated into a fluid portion, the serum, and a semi-solid portion, the fibrin, containing the corpuscles. Coagulation prevents excessive bleeding from slight cuts, etc.

7. The Red Corpuscles. — The red corpuscles in human blood are minute, flat, circular disks, concave on both sides, having a diameter of about $\frac{1}{3200}$ of an inch and a thickness of about $\frac{1}{12000}$ inch.² If placed edge to edge, rather more than ten millions of them would be required to cover a space one inch square. When one of these corpuscles is examined under a powerful microscope, it appears of a pale yellowish color; but when several are seen lying one on another, or *en masse*, the redness becomes obvious, and thus these little bodies give to the blood its uniform red color.

8. These corpuscles have a sort of spongy framework, and are very soft, flexible, and elastic. They readily change their shape in passing through the smallest blood-vessels and apertures narrower than their own diameters, and resume their proper shape immediately afterward.

9. In composition the red corpuscles are found to consist of about $56\frac{1}{2}$ parts water, and $43\frac{1}{2}$ parts solid

¹ *Serum* is composed of water, 90 parts; proteid substances, 8 to 9 parts; fats, extractives, etc., 1 to 2 parts. Proteids are albuminoid substances; the name applied to that form most largely existing in the blood is *para-globuline*.

² In different animals the red corpuscles vary in size; in birds and in reptiles they are oval in shape and larger than in man.

matter;¹ and each of them should be considered as a minute, spongy, semi-fluid or semi-solid, jelly-like mass, rather than as a tiny bag or sac containing fluid.

10. The White Corpuscles. — These corpuscles are ex-

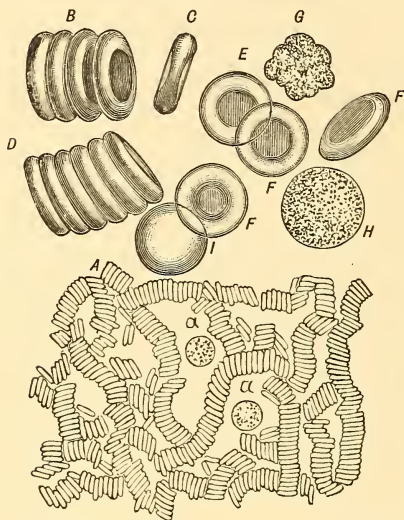


Fig. 29. Red and white Corpuscles of the Blood magnified.

EXPLANATION.

A, moderately magnified corpuscles. At *a* and *a* are two white corpuscles. The red ones are arranged like coins in rolls. B, C, D, E, F, are highly magnified red corpuscles, in various positions. I, a red corpuscle distended into a sphere. G, H, white corpuscles, much magnified.

tremely irregular and ever-changing in form, of a yellowish-white color, and a little larger than the red, being $\frac{1}{2500}$ of an inch in diameter. The white corpuscles are not so numerous as the red, the proportion being about as one to five hundred.

11. While the shape of red corpuscles is changed only by influences from without, such as pressure, that of the white corpuscles undergoes constant alteration from changes taking place in their own substance. They also exhibit a peculiar

migratory power (and in this they much resemble a minute animal organism found in great numbers in stagnant

¹ The solids are organic matters, in 100 parts of which have been found *hæmoglobin*, 90.54 parts. This substance possesses a strong affinity for oxygen, and readily absorbs it or unites with it; but as the tissues have a still stronger affinity for oxygen, they absorb it from the red corpuscles, and, in return, replace it with car-

water), often getting out of the smallest blood-vessels (*capillaries*) and becoming scattered in the interstices of the surrounding tissues, where, in consequence of their adhesiveness, they become fixed, undergo changes, and become parts of the tissues. White corpuscles in the blood of all animals are very nearly equal in average size.

12. Quantity of Blood. — In the human body it may be said that from one-tenth to one-thirteenth of its weight is that of blood, of which, according to Ranke, one-fourth is distributed in the heart, lungs, large arteries, and veins; one-fourth in the liver; one fourth in the skeletal muscles; and one-fourth in the remaining organs and tissues.

13. Quality of the Blood. — While the blood is normally found to contain all the elements needed for the nourishment of the entire system, and is being constantly added to by constituents derived from food and from the air, yet there is probably as much variation in its quality as in its quantity in different individuals. "The hygiene of the blood requires proper food, exercise, cleanliness of skin, right living, and sound organs, and then the system will not fail to make use of its natural powers of construction, elimination, and repair." Blood may become so much impoverished — thin and watery — from neglect of hygienic attention, as to render health impossible; and such conditions are often inherited.

14. The Lymph. — In addition to the blood, and intermediate between it and food, there is another fluid found

bonic acid. Further, the color of the blood is due to *hæmoglobin*, which contains a considerable proportion of iron oxide. As the blood flows through the capillaries surrounding the air-cells in the lungs, the *hæmoglobin* combines with the oxygen of the air, becoming of a bright-red color.

widely distributed in the body. This fluid, known as *lymph*, closely resembles the plasma of the blood in composition, and is contained in the *lymphatic* vessels. Lymph represents some of the ingredients of the blood and some of the waste matter resulting from the constant wear of the tissues. It has been described as "blood minus its red corpuscles which becomes changed on entering the lungs and mingling with the current."

15. *Lymphatic vessels* resemble exceedingly small veins, and all parts of the body which have blood capillaries, except perhaps the bone, brain, spinal cord, cartilages, and tendons, have also lymphatic vessels mingling with the blood vessels. In their course the lymph vessels form in some parts of the body, as about the neck, groins, and arm-pits, numerous small, solid bodies called *lymphatic glands*. After twining about through the tissues and amidst glands, the lymphatics pour their contents into the thoracic duct which empties its liquid into the great vein at the left side of the heart, from which it is sent to the lungs to be purified before entering the general circulation.

CHAPTER X.

THE CIRCULATION.

1. **The Circulatory Apparatus.** — For the purpose of conveying throughout the body the blood, the circulation of which is essential to growth, and by which fresh material is deposited in place of that which has worn out or become unfit for use, there is in the body a circulating apparatus

analogous to that by which cities are supplied with water.

2. A powerful and complex machine, the *heart*, receives

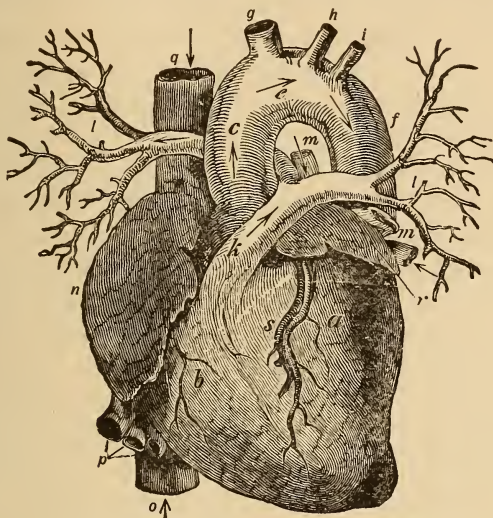


Fig. 30. The Heart and large Blood Vessels.

EXPLANATION.

q, the descending vena cava.
o, the ascending vena cava.
n, the right auricle.
b, the right ventricle.
k, the pulmonary artery.
l, l, the right and left branches of this artery, going to the lungs on either side of the chest.
m, m, the veins of the lungs, which return

what the artery sent in, to *r*, the left auricle.
a, the left ventricle.
c, e, f, the aorta, or great artery of the body, rising out of the left heart.
g, the arteria innominata.
h, the left common carotid artery, going up the side of the neck to the head.
i, the left subclavian artery, going to the left arm.

Note.—The arrows show the course the blood moves in each of the vessels demonstrated with the heart: *n*, the right auricle; *m, m*, veins of the lungs; *s*, the left coronary artery; *p*, the veins returning blood from the liver and bowels.

the blood into its cavities, and, acting as a forcing-pump, propels it into an extensive series of tubes, the *arteries*,

by which it is conveyed to all parts of the body to give it nourishment. A network of very fine tubes, the *capillaries*, variously arranged, connects the arteries with another set of large pipes, the *veins*, and the latter collect all the blood, after it has been used, in order to return it to the heart, which then pumps it into the *lungs*, where it becomes aerated and gives off impurities. Thus during life the blood is in constant motion. "From the heart, as a centre, a current is always setting toward the different organs, and from these organs a current is constantly returning to the heart."

3. The Heart. — The heart is roughly estimated to be about the size of the fist. Its weight is from ten to twelve ounces in the adult, and it increases slightly in size and weight with advancing years.

4. It is conical or pear-shaped, and is suspended in the chest a little to the left of the centre-line, its base upward, and its apex or point downward, on a level with the space between the fifth and sixth ribs. It is composed of muscular tissue which contracts regularly at equal intervals of time. It is enclosed in a sac of serous membrane called the *pericardium* (Gr. *peri*, around ; and *kardia*, the heart). In the pericardial sac is a small quantity of fluid—a teaspoonful or two—which lubricates the surface of the heart and of the sac, and admits of free movement without friction.

5. Muscular Structure of the Heart. — The muscles of which the heart is composed are different from the general muscles of the body in several particulars. Their fibres are not continuous and separable, but join each other in various directions. Again, they seldom have a covering or sheath.

6. There are two layers of muscular fibres, the superficial and the deep. The former run spirally around the heart, forming a figure 8. These subserve the purpose of contracting the heart in such a manner as to cause it to empty its contents rhythmically, as will be seen later. The deep layers are circular in form.

7. **Cavities of the Heart, Valves, etc.**—The human heart (and that of all mammals and birds) has four distinct cavities. The right half of the heart is designed to propel the blood into the lungs, the left half to propel it through the arteries to all parts of the body. Hence, the right side of the heart is known as the *pulmonary* (Lat. *pulmo*, a lung) side, and the left the *systemic*. Each side contains two cavities, an upper and a lower one. The upper cavities are known as *auricles*, the lower ones as *ventricles*.

8. While the right side and the left side are entirely separated by a wall in which there is no opening, the auricles and ventricles are not so separated. They are so arranged as to allow the blood to pass freely from each auricle to each ventricle (but not from the ventricle to the auricle) by means of little doors or valves composed of strong fibrous tissue prolonged into cords which are attached to the walls of the heart. These openings are known as the *auriculo-ventricular* openings. The valve between the right auricle and right ventricle is commonly known as the *tricuspid* (i.e., three-pointed) *valve*, it having three leaflets; that between the left auricle and left ventricle, the *mitral valve*, having two leaflets which, when open, are supposed to resemble a mitre.

9. The muscular walls of the left side of the heart are thicker and stronger than those of the right side, since

more force is required to drive the blood through the arteries than merely to receive it back from the veins and propel it to the lungs, as is done by the right side. This

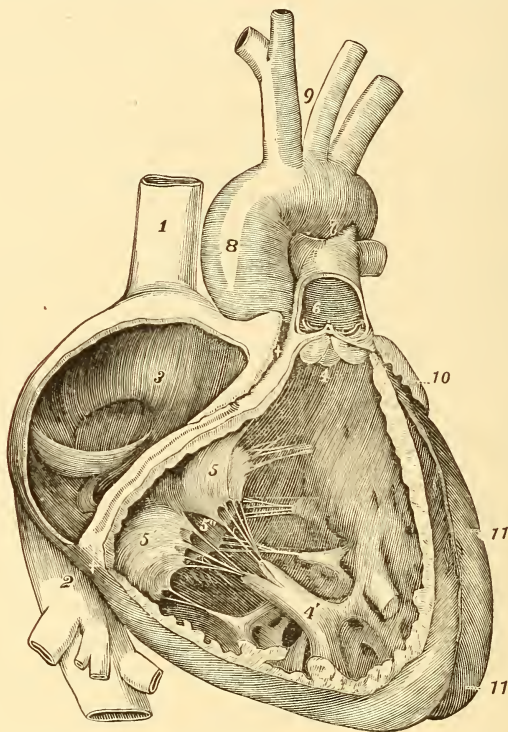


Fig. 31. Interior of the Right Side of the Human Heart.

EXPLANATION.

1, *superior vena cava*; 2, *inferior vena cava*; 3, *interior of the right auricle*; 4, *semi-lunar valves of the pulmonary artery*; 4', *papillary muscle*; 5, 5', and 5'', *cusps of the tricuspid valve*; 6, *pulmonary artery*; 7, 8, and 9, *the aorta and its branches*; 10, *left auricle*; 11, *left ventricle*.

is especially true of the left ventricle, whose work it is to propel the blood through the whole system.

10. Besides the valves already mentioned, there are also valves in the *aorta* (the main trunk of the arterial system), and in the *pulmonary artery* (the artery conveying blood to the lungs).

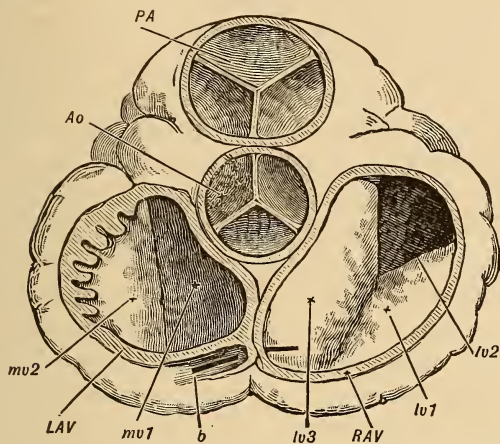


Fig. 32. The Orifices of the Heart seen from above, the Auricles and Great Vessels being cut away.

EXPLANATION.

P, A, pulmonary artery, and *Ao*, aorta, with their semilunar valves. *R. A. V.*, right auriculo-ventricular orifice, showing the three folds (*lv*, 1, 2, 3) of the tricuspid valve. *L. A. V.*, left auriculo-ventricular orifice, showing its mitral valve of two flaps at *m. v.*, 1 and 2. A piece of whalebone at *b* passes into the coronary vein. The tooth-like appearance of the left side of *L. A. V.* is due to the fact that the section of the auricle is carried through the auricular appendage seen on the exterior surface of the heart.

11. In a healthy condition of the heart, all of these valves work harmoniously and perfectly; but in certain organic diseases they become deranged, thus leading to serious and often fatal results.

12. Course of the Blood in Circulation. — The minute veins in all parts of the body collect the impure blood. These veinlets unite and form larger branches which finally cul-

minate in two great veins known as the *superior vena cava* and the *inferior vena cava*, which open into the *right auricle* of the heart. When the auricle is filled, its contraction drives the blood through the tricuspid valve into the *right ventricle*, whence it is forced by contraction of that ventricle through the *pulmonary artery* into the *lungs*. Here the blood is distributed by the branches of the artery (numerous hair-like tubes) among the air cells, and after its change into arterial blood from contact with the air inhaled, it is conveyed by the *pulmonary veins*¹ to the *left auricle*. By the contraction of the *left auricle* the arterial blood is driven through the *mitral* valve into the *left ventricle*, by the contraction of which it is propelled through the main artery of the heart (the *aorta*) and its branches throughout the whole arterial system, until at last it enters the *capillaries* (the hair-like network of tiny blood-vessels connecting the arteries and veins) for the nourishment of the tissues. Having performed its mission by giving up its nourishing elements, and having received in exchange the products of decay and disintegration, the blood commences at the extremities of the venous system its return to the right auricle, whence it is again sent to the lungs for purification.² Thus we have traced the course of the blood on its endless round.³

¹ To avoid confusion, it is well to state that the only artery that conveys *venous blood* is the *pulmonary artery*, and the only veins that convey bright or *arterial blood* are the *pulmonary veins*.

² In short, the course of the blood is as follows: From the right side of the heart to the lungs; thence to the left side of the heart; thence to all parts of the body; thence back to the right side of the heart. It will be noticed that the right side never contains anything but dark, *venous* blood, and the left side always contains bright, *arterial* blood.

³ In 1602 William Harvey began investigations upon living animals, and in 1616 discovered the circulation of the blood. Prior to that time portions of the circulatory apparatus and their functions had been described by several persons.

13. Action of the Heart. — The heart may be viewed as a pump, a part of whose action is simply mechanical. Continuous in its action, it would not vary a beat in frequency and force were it not for certain changes in the system. Fortunately, it can accommodate itself measurably to changed conditions in vital processes. In the normal state the action is regular, and the quantity of blood ejected at each beat is the same.

14. The alternate contractions and dilations of the auricles and ventricles are technically termed *the systole* and *the diastole*. More properly, the *diastole* is a pause between the movements — a period of slight rest.

15. By opening the chest of an animal and keeping up artificial breathing, it has been made possible to see a heart in action ; and the following phenomena have been observed : First, a filling up of the great veins which open into the heart ; then a contraction of these veins and a filling up of the auricles, followed by a contraction of the auricles and a filling of the ventricles, which is called the *auricular systole*. Immediately follows the contraction and shortening of the ventricles, known as the *ventricular systole*. During the contraction of the ventricles, the aorta and the pulmonary arteries expand with the columns of blood thrown into them, and the heart rolls or twists to a slight degree from left to right. This twisting or rolling movement is due to the "figure of 8" arrangement of the muscular fibres previously mentioned.

16. As the ventricles become empty, they lengthen out again ; and this period of relaxation previous to another series of movements is called the *diastole*. At this time, also, the heart turns back again, or, rather, untwists.

Short as are these periods of relaxation, they afford, in the aggregate, much rest to the muscles of the heart.¹

17. Sounds of the Heart. — When the ear is applied to the chest over the heart, two sounds can be heard, viz., a long, deep sound, and a short, sudden one, succeeded by a pause, which is followed by a repetition of the same sounds. The space of time between the first and the second sound is so short as to be scarcely measurable, but there is an appreciable pause before both sounds are repeated. These sounds have been likened to those made in pronouncing the syllables *lūb-dūb*. It is difficult to determine the cause of the first sound, but it is generally agreed now that the second sound is due to the closing of the *semi-lunar valves* of the aorta and the pulmonary artery, after the blood has passed into them.

18. Changes in the rhythm, intensity, or pitch of these sounds indicate to the physician the character of any disturbance or diseased condition of the heart.

19. Cardiac Impulse. — What is called the *cardiac or heart's impulse* is the striking of the lower, pointed end, or apex, of the heart against the walls of the chest. This occurs at the time of the contraction of the ventricles (*ventricular systole*), and is most easily felt a little to the left of the middle line of the chest, between the fifth and sixth ribs.

20. Causes influencing the Heart-Beat. — The average rate of the human pulse, which is a measure of the heart-beat, is 72 a minute. Children's pulses are more rapid than those of adults. During middle life the pulse varies from 70 to 80, being about 10 more in females than in males.

¹ It has been estimated that each pause is about one-third of a second in duration, and that the heart thus obtains more than nine hours of total rest daily.

21. The heart does not always beat with unvarying precision. Besides changes that may have been produced by disease, influences which operate upon the nervous system affect the heart also. Joy, sorrow, fear, anger, all nervous excitement affect the rapidity of the heart's action; and hence, sudden excitements are to be carefully avoided as especially dangerous in diseased conditions of the heart. The increase in frequency is accompanied by loss of force, and *vice versa*.

22. "It is true that the heart is made to endure many variations, but frequent and rapid changes of heart-beat are to be avoided." Later the effects of stimulants will be considered, and their effect upon the circulation stated. Just here, however, it is desirable to state that "there is no effect of *alcohol* more insidious than the nervous thrill it imparts to the action of the heart," and that its frequent or continued use is attended with the most disturbing and injurious results.

23. Muscular activity, the position of the body, the temperature of the air, the quantity and kind of food, and the age and sex of the individual affect the rapidity of the action of the heart and vary it in force and character. Again, the heart's action varies with the temperament, appearing to be slower in proportion as the individual is cool and deliberate in his judgments. As examples of this, it is said that the pulse of Napoleon Bonaparte averaged only forty-four per minute, and that of the Duke of Wellington about the same. On the other hand, in some persons of excitable, nervous temperament the pulsations number ninety or more per minute. Very quick action tends to exhaust the heart.

24. **The Nerve Force of the Heart.** — We have thus far con-

sidered the action of the heart and the phenomena of the circulation from a mechanical point of view. But this beautiful mechanism would be useless without the force derived from the nerve centres.

25. In the first place, in the heart itself there are three sets of nerves. The *first* is that set supplied by the masses of nerve cells (called *ganglia*) in the substance of the heart. The *second* set comes from that part of the nervous structure called the *sympathetic*,¹ which supplies force to *involuntary muscles*—the heart, etc. The *third* consists of branches of a nerve which originates in the brain and comes directly to the heart, and is known as the *pneumo-gastric* nerve (Gr. *pneuma*, breath; and *gaster*, the stomach).

The part which each set takes in regulating and directing the action of the heart has been studied, and the latest researches seem to prove firstly, that the contractions regularly “depend upon the ganglia lodged in its substance;” secondly, “that the influence which increases the rapidity of its action is exerted through the *sympathetic nerves* ;” thirdly, “It is quite certain that the influence which arrests the heart’s action is supplied by the pneumo-gastric.”²

26. That the nervous system is the controlling influence may be shown, as before stated, by the effect the emotions may have upon the circulation and upon the action of the heart. Fear blanches the countenance, while joy quickens the circulation. Extreme fear or sudden sorrow may arrest the heart’s action. It is well to remember this in our daily intercourse with friends.

¹ The *sympathetic nervous system* consists of a double chain of nerve cells or ganglia, running from one extremity of the body to the other, not including the limbs.

² Huxley.

27. It is a senseless and possibly a wicked act to endeavor to startle or frighten a person suddenly, or to bring bad news unguardedly. A physical blow can be sustained better than one aimed at that most sensitive part of the body, the nervous system. When we consider the intimate relation between the mind and the body, and realize that mental shock reacts upon the body, sometimes even to death, how careful we should be to avoid the danger of such a possible result of a stupid trick!

CHAPTER XI.

THE CIRCULATION. (*Continued.*)

1. **The Arterial System.**—The *aorta*, or main artery, is about five-eighths of an inch in diameter, and rises from the left ventricle of the heart. It ascends perpendicularly about three inches, and then, curving in the form of an arch, descends. From the arch it gives off two large branches, one to each arm, and two others to supply the head, one going up on either side of the neck. Descending along the left side of the spine, it sends out branches to the ribs; and when opposite the stomach, a branch is sent out to that organ. In like manner, branches convey blood to the liver, spleen, and the other intestines. At the lower end of the spine the aorta terminates by dividing into two large branches, one of which goes to each thigh.

2. At the elbows and at the knees each main branch

divides into two, and these passing down, one on each side of a limb, again subdivide and furnish a small artery for each side of each finger, thumb, or toe.

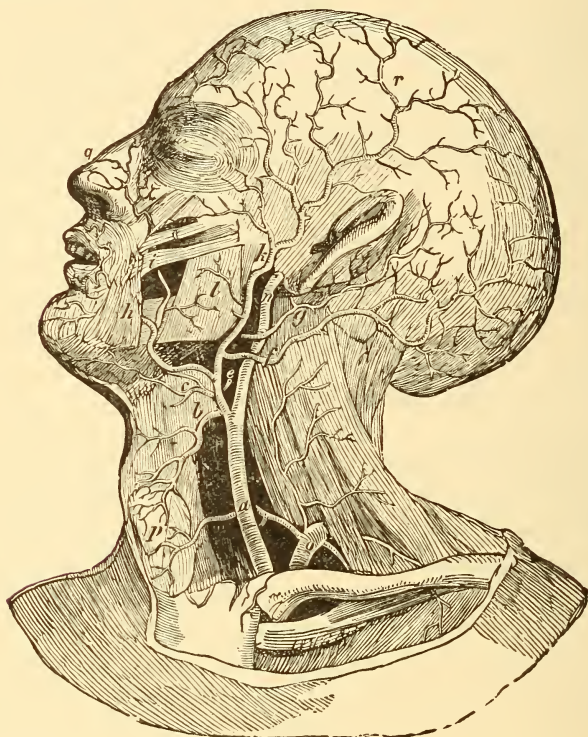


Fig. 33.

EXPLANATION.

- a*, the trunk of the *left common carotid artery*.
- f*, the *occipital artery*, going to the muscles of the back of the head.
- b*, the *larynx*, or vocal box.
- n*, the *external carotid*, branching outward.
- k*, the *temporal artery*, felt beating in the temple.
- g*, the *nasal artery*.
- r*, the termination of the *temporal artery* in twigs on the top of the head.

3. Throughout the body, however, arteries of various sizes branch out from the main trunks to supply the different organs, the muscles, the bones, skin, etc.

4. **Structure of the Arteries.**—The arteries are tubes whose walls are strong and elastic. The outermost coat of these vessels consists of strong connective tissue; the middle coat, of elastic fibres and involuntary muscular tissue; and the innermost coat, of a delicate, smooth membrane which lessens the friction in the flow of blood through the tube.

5. The heart, although a powerful organ, would not be able to force the blood through the whole system of the arteries, and back to itself again by the veins, without assistance. The maintenance of the circulation, while mainly due to the action of the heart, is aided by the elastic and muscular middle coat of the

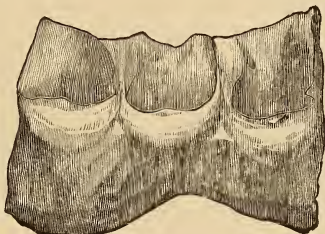


Fig. 34. The Semilunar Valves of the Pulmonary Arteries, the Vessel being cut and laid open.

arteries. At each contraction of the heart the blood driven into the arteries must push forward the blood already contained in them; and this results in sufficient resistance to cause a pressure outward and distension of the elastic walls of the arteries. After each throb of the heart and removal of its pressure, the muscular coat of the arteries contracts and exerts, in turn, a pressure upon their contents which not only propels the blood onward, but also backward toward the heart; and if it were not for the valves located where the great arteries open into the heart, the blood, or a portion of it, would be driven

back into that organ. The slightest backward pressure, however, causes these valves to close, and the contraction of the arteries thus serves to keep up the onward movement of the blood till the next impulse is given it by the heart.¹

6. The successive dilations and contractions of the arteries give rise to what is known as the *pulse*, which, while everywhere present in the arteries, can be felt only at points where they run near the surface of the body, as in the wrist, in the neck, in the temple, in the ankle, etc. The pulse is most frequently felt for in the wrist, simply because that is the most convenient place.

7. When an artery is cut, the red blood emerges from it in jets corresponding in numbers and time with the beats of the heart ; but the dark outflow from a cut vein is slower, and not accompanied by jerks. These differences of outflow serve to distinguish between a wounded artery and a wounded vein.

8. Owing to the elastic nature of its walls, an artery does not retract and become closed when cut, as a vein does ; and hence it is well to know that hemorrhage from an artery may be stopped only by pressure applied upon it *between the heart and the wound*.

9. **The Capillaries.** — Between the smallest arteries and veins, and continuous with each of them, there is a network of extremely fine blood-vessels, called *capillaries* (Lat. *capillus*, a hair). Through this network of hair-like vessels the blood passes from the arteries to the veins.

10. The large arteries, as we have seen, divide and sub-

¹ The only arteries which have valves are the aorta and pulmonary artery which spring from the heart, and the valves are situated at the points where these arteries open into the heart. These valves are pouch-like, similar to those of the veins.

divide continually. Their branches decrease in size with every division, and their walls undergo changes in structure. The smaller the artery becomes, the less muscular tissue it contains; and finally, in these smallest blood-vessels, the capillaries, we find none of it. Their walls are composed of a single thin membrane, and their number is beyond computation. They permeate all parts of the body except the hair, nails, substance of the teeth, the cartilages, and the outer layer of the skin. Indeed, so thickly strewn are they in the body that the point of the finest needle cannot anywhere be inserted between them. In diameter they are only about $\frac{1}{3000}$ of an inch, or just large enough to permit the corpuscles to pass through them; and the interspaces between them are occupied by the various tissues.¹

11. An examination of a frog's foot under a microscope shows most beautifully the circulation of the blood through the capillaries. A current of blood from the arteries courses along, carrying with it the corpuscles. The branches finally become so small that the corpuscles can only pass in single file, and here the current becomes slower and seemingly uncertain; but the corpuscles pass on toward the veinlets and enter the current of the venous blood.

12. In the capillaries the blood undergoes a very remarkable and important change. "The circumstance that all the tissues are outside the blood-vessels, by no means interferes with their being bathed by the fluid

¹ The capillaries are too small to be seen without the aid of a microscope, and hence before the discovery of that instrument the anatomists were puzzled to explain how the blood passed from the arteries to the veins, as they could detect no direct communication.

which is inside the vessels, for the walls of the capillaries are so exceedingly thin that their fluid contents readily exude through them and permeate the tissues in which they lie.”¹ In this way the blood gives up to the various tissues the oxygen and nutritious elements which each needs, but furthermore absorbs from them, through the walls of the capillaries, carbonic acid gas and other waste products. Charged with carbonic acid, the blood loses its bright color and becomes dark. It is in the capillaries then that the *arterial blood is rendered venous*, their thin, moist walls allowing the change to be effected with perfect ease.

13. The Veins. — After passing through the capillaries, in which the blood gives up its nutriment in exchange for waste products, it flows on into the veinlets and then into still larger branches or *veins*.

14. The walls of the larger veins consist of three coats, but the middle coat contains much less muscular and elastic tissue than that of the arteries; and hence the veins are flaccid and yielding. When cut across or emptied, they collapse.

15. Unlike the arteries, the veins have valves on their internal surface which prevent the blood from *flowing backward*. These valves are pouch-like folds of the inner wall of the veins, and during the onward flow of the blood they offer no impediment to its passage; but if a vein be pressed upon so as to drive backward the blood which it contains, the pouch swings out from the wall and opposes further backward flow. When a vein is thus pressed upon, several little knot-like swellings make their appearance at different points in its length, and these are the

¹ Huxley.

dilations of the walls above a valve which resists the backward pressure. In the veins of the extremities the valves are especially numerous, since the weight of the columns of venous blood would tend to interfere with the onward circulation but for this provision. Each valve serves to check the slightest tendency toward a backward flow, and thus the work is distributed.

16. The veins are more numerous than the arteries, and can retain nearly twice as much blood as the latter. As a rule, they lie nearer the surface of the body than the arteries do, and are recognizable by their blue color.

17. The current of blood in the veins is more rapid than that of the capillaries, but slower than the arterial current. The flow through the veins is continued by the pressure of the blood in the capillaries, the contraction of muscles through which the veins pass, the suction power of the auricles, and by the expansion of the chest in breathing, which tends to draw the blood into the lungs.

18. Commencing in the capillaries, as we have learned, the veins unite into larger branches, and these into still larger ones, all converging toward the heart as do the branches of a tree towards its trunk. Finally they all become united in two great veins, the *vena cava descending*, formed by the veins of the head and arms, and the

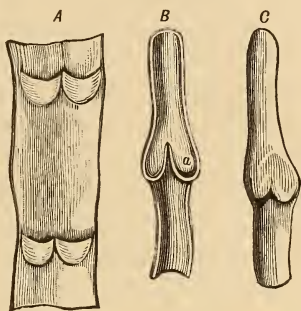


Fig. 35. Showing the valves of veins.

EXPLANATION.

A, part of a vein laid open, with two pairs of valves.

B, longitudinal section of a vein, showing the valves closed.

C, portion of a distended vein, exhibiting a swelling at a pair of valves.

vena cava ascending, formed by those of the legs and trunk. These two great trunks connect with the right auricle of the heart.

19. Vaso-Motor Nerves. — *Vaso-motor nerves* (Lat. *vasa*, vessels) are those which control the movements of the muscles lying in the walls of the blood-vessels. From the sympathetic nervous system, nerve-fibres are distributed to the arteries and capillaries, regulating their contraction, and, consequently, the amount of blood which they contain. Under the influence of these nerves the arterial coats are kept in a state of permanent constriction; but when the nerve-fibres are cut or otherwise lose control of an artery, it immediately dilates and allows the entrance of more blood, giving rise to a swollen condition called *congestion*.

20. There is a communication between the vaso-motor nerves and the central nervous system by means of which the former become subservient to the latter; and thus the supply of blood to each organ is regulated and adapted to its necessities. If the nerve stimulus is such as to contract the arteries and capillaries of the skin, pallor is produced. On the other hand, if the nervous control be partially withdrawn, the capillaries dilate, more blood enters them, and a ruddy glow or "blush" is the result.

21. Animal Heat. — We have seen that it is necessary for the growth and nutrition of the body that the blood shall flow to its every part. It is also essential that the temperature of the blood shall be maintained at a regular degree. Now in the destructive changes in the tissues — in the combustion in which oxygen is consumed and carbonic acid gas is given off — heat is evolved. Exactly

where this process takes place is not positively determined, but we know that it occurs between the time when the nutritive elements are appropriated by the tissues and the time when the waste products are given up to the venous capillaries to be carried into the veins.

22. The greatest amount of heat is generated in the muscles, as they constitute so large a part of the body and are so frequently in motion. The secretory glands — the liver, kidneys, etc. — being so full of capillaries, come next to the muscles in the amount of heat production. Heat does not originate in the blood itself, but is imparted to it.

23. From the slight changes occurring in bone, cartilage, and connective tissue, but little heat is generated in them. The digestion of food in the alimentary canal also furnishes a small amount of heat.

24. If there were no means by which the heat thus produced could be regulated, the body would soon be consumed with "living fire." While loss of heat may be produced by contact of the body with cold objects, by radiation from its surface, etc., its due regulation depends mainly upon the perspiratory action of the skin and the exhalation of watery vapor by the lungs. The surplus heat being thus carried off, the temperature is maintained at a regular degree ($98\frac{1}{2}^{\circ}$ F.), and this varies none through life, excepting in disease.¹ It will be seen in another chapter that proper clothing, bathing, exercise, and food assist in regulating the bodily temperature.

¹ Aged persons are generally thought to be more susceptible of cold than the young. The heat of human beings has, however, been proved to be very nearly the same whatever their age or race, whether on a cold winter morning or on the most sultry day of summer.

CHAPTER XII.

HYGIENE OF THE BLOOD AND CIRCULATION.

1. **Quality and Quantity to be Maintained.** — “For the life of the flesh is in the blood,” is an expression often quoted from the Scriptures. In order that the blood may indeed be the fluid of life, that it may contain the elements necessary to the proper nourishment of the body and support of its nervous and muscular vigor, a due amount of proper food and pure air must be regularly and continually received into the body. Furthermore, in order that the blood may circulate freely and with sufficient rapidity, the body must be exercised.

2. If food be insufficient or of poor quality, the blood becomes impoverished; and if the air inhaled be impure or deficient in oxygen, the blood deteriorates accordingly. Proper food, pure air, and sufficient exercise are the means, in general, by which the quality, quantity, and circulation of the blood are to be healthfully maintained. In the chapters treating of *food*, *air*, and *exercise*, the relations of these to pure, rich, and freely-circulating blood are more fully noticed.

3. **Effects of Pressure on the Veins.** — The veins, as we have seen, are largely distributed near the surface of the body, and are therefore peculiarly subject to the influences of pressure, changes in the temperature of the air, etc. Having soft, yielding coats, the veins are affected by the

slightest pressure ; and if clothing is so tight as to produce any noticeable pressure, it will obstruct the flow of venous blood toward the heart, and thus retard the circulation. If the return of venous blood from any part is interrupted, the supply of arterial blood to that part is proportionately diminished, and it suffers accordingly. Tight garters are a common cause of cold feet, and thus make the body generally uncomfortable. Tight sleeves, tightly fitting garments of whatever kind, exerting a perceptible pressure, disturb the circulation.

4. The great veins (*jugulars*) which return the blood from the head lie very near the surface on each side of the neck. Compression of these veins by tight collars produces congestion of the blood vessels of the entire brain ; and such engorged condition is manifested by a sense of pressure or fulness in the head, by dizziness, or by headache. Moderate and continued pressure will impede the circulation in the brain to an extent sufficient to weaken the whole nervous system.

5. **Proper Distribution of the Blood.** — If the skin is not properly cared for and its pores become obstructed, its natural action will be interfered with, and less blood will enter its minute blood vessels. As a consequence, too much blood may be centred in or about internal organs ; and hence, to produce a healthful balance, the skin should be kept clean and active, and the limbs and muscles should be properly exercised. In this way internal congestion is relieved by attracting blood to the surface.

6. **The Heart and Mental Excitement.** — Frequent excitement tends eventually to cause heart-trouble. While the

heart is capable of enduring many variations in its action, caused by mental excitement, yet frequent and rapid changes of its beat should be avoided.

7. "Even when greatly obstructed or weakened, the heart often succeeds, with the intelligent co-operation of the patient, in keeping the blood moving through the arteries for many years. Often in disease it has to force the blood through a shrivelled opening not much larger than a goose-quill, and this it does by working harder, thus causing its own enlargement. But the enlargement may at length cause a dangerous thinning of some portion of its walls. Sometimes the walls of the aorta lose their elasticity and swell out into a great, thin tumor (*aneurism*). Sometimes the tough fibres of the heart are changed into fat. In such cases a fatal termination may long be delayed by avoiding undue excitement."

8. **Effects of Alcohol on the Blood.** — When alcohol¹ is taken into the stomach, it does not remain there to be digested, but some of it is immediately absorbed into the blood and carried into the circulation. Since the blood is so largely composed of water, for which alcohol has a great affinity, the action of alcohol upon the blood is very marked. It absorbs water from the corpuscles, which, if much exposed to its action, shrivel and thus become less capable of holding and carrying oxygen and of taking up carbonic acid from the blood. Thus it will be seen that the direct action of alcohol is to interrupt or prevent that interchange of substances in the capillaries upon which the nourishment of the tissues and the elimination

¹ For a description of alcohol and alcoholic beverages, see the chapter upon "Drinks (continued). — Narcotics and Stimulants," p. 184.

of waste particles depend. Again, as the capacity of the corpuscles as carriers of oxygen is diminished, oxidation throughout the body is partially arrested, less carbonic acid is exhaled, and the temperature of the blood is reduced.

9. The habitual presence of alcohol in the blood deteriorates its quality, and thereby tends directly toward diseased conditions which manifest themselves particularly in the heart, liver, kidneys, and lungs, they being the centres of the circulation. Deterioration or impoverishment of the blood is probably the first step toward starving the tissues which the nutritive fluid should feed.

10. "It appears that the fibrin of the blood is affected by the alcohol as follows: If it is exposed to strong alcohol, it is coagulated in the blood-vessels, and thus tends to clog the circulation in the capillaries.¹ If it is exposed to very dilute alcohol for any considerable length of time, as in the case with habitual drinkers, it loses its power of coagulation, so that the blood wastes freely from breaks or cuts of these vessels. This action of alcohol upon the blood is well known to surgeons, who, because of these conditions, hesitate to perform such operations upon alcoholic patients as may safely be performed upon those whose blood is not contaminated by alcohol."²

11. **Effects of Alcohol on the Heart and Blood-vessels.** — Alcohol exerts a paralyzing influence on the *vaso-motor* nerves

¹ So greedy for water is it (alcohol) that it must first be diluted before it can be absorbed. If it be not so diluted, it will seize the water from the tissues to which it is applied, and will harden and coagulate them. In this way it may even be made to coagulate the blood itself, and, in some instances of rapid poisoning by it, death has occurred from the coagulation of blood within the vessels or in the heart. — *Richardson*.

² "Alcohol: Its effects on Body and mind." — *E. F. Brown, M.D.*

(those which control the muscular coat of the arteries and capillaries). Paralysis of these nerves causes relaxation of the muscular coats of the small arteries, and they become enlarged and swollen with blood in every part of the body. This enlargement removes the natural resistance to an undue rapidity in the flow of blood through the vessels which act as a balance-wheel to the action of the heart; and the latter organ, released from this natural restraint, is driven at an unusual rate and suffers from the "wear and tear."¹ Habitual or frequent stimulation of the heart's action by this agent tends to exhaust or weaken its muscular power. Consequently, a person after imbibing alcohol, though he may feel unusual vigor and activity from the first effects, will soon suffer from a reaction in which the heart will act with less than natural force, the brain feel tired, and the muscles feeble.

12. Alcohol, from constant use, causes changes in the muscular structure of the heart, rendering it weaker and less able to contract forcibly. Sometimes the effect is to soften the muscular heart and to fatten it, a process known as *fatty degeneration*. An unusual effort of a heart in this condition may cause its rupture, and terminate in sudden death.

13. In other chapters it will be learned that the habitual use of alcoholic liquors tends to weaken the power of the will, to injure the brain and nervous system, the muscles, and, in fact, the entire organization.

14. **Effects of Tobacco.** — Tobacco tends directly to disturb the sympathetic nervous system on which the heart

¹ If the number of beats of the heart in twenty-four hours is about 100,000, the effect of an ounce of pure alcohol is to increase the number to about 104,000 in the same length of time. The cause of this is found partly in the action of the alcohol on the blood-vessels and partly in its effect upon the nerves of the heart itself.

depends for healthy action. Irregularity and palpitation are often caused by it, and a large percentage of tobacco users are more or less troubled with irregularities of the heart, the evil effects being intensified if the heart is naturally weak. It is an active agent in causing heart and artery disease, and its effects are further shown in increased fluidity of the blood and resistance to normal coagulation.

Suggested Points for Questions.

CHAPTER IX. — 1. The vital fluid — where. 2. Plasma, corpuscles. 3. Corpuscles — functions, etc.; blood — nutrition, waste. 4. Interchanges necessary to life — analogy; reception and elimination of material. 5. Varying composition of blood — cause, color. 6. Coagulability — mould, clot in serum; fibrin — nature; coagulation and bleeding. 7-9. Red corpuscles — form, size, number, color, structure, changes in shape. 10, 11. White corpuscles — form, size, number, changes, migration, form tissue. 12. Quantity of blood, distribution in body. Quality of blood — variation; good blood, impoverishment. 14, 15. Lymph, lymphatic vessels, glands; relation to thoracic duct and circulation.

CHAP. X. — 1. Circulatory apparatus — purpose. 2. The central organ or pump; arteries, capillaries, veins, lungs — functions; constant motion. 3, 4, 5, 6. Size, shape, weight, location, tissue, and contractility, pericardium and fluid, peculiarity of muscles, “figure of 8” arrangement, circular layers — purpose, 7, 8. Cavities; right and left side separated — office; pulmonary and systemic; relation of auricle and ventricle — valves, course of blood. 9. Right and left walls compared; left ventricle strong. 10. Valves opening into aorta and pulmonary artery. 11. Valves in health and disease. 12. Course of circulation. 13. Regularity of heart-action, uniform ejection. 14. Systole and diastole. 15. A heart in action — phenomena; twisting motion; periods of rest. 17. Sounds of heart — cause. 18. Sounds indicative. 19. Cardiac impulse — cause. 20. Rate of beat — pulse in children, adult, female. 21, 22. Variation in beat — cause, avoidance; “alcoholic thrill” — effect. 23. Principal influences affecting heart-action; exhaustion. 24, 25.

Nerve-force of heart—ganglia, sympathetic nerves, etc.,—offices of each. 26, 27. Nervous system controls heart—emotions and effects; danger of shock—possible fatality.

CHAP. XI. — 1. Aorta and branches—head, trunk, intestines, extremities. 2. Duplex arterial supply of arteries in extremities. 3. Arteries of body in general. 4. Structure of arteries. 5. Elasticity of arteries aids heart; functions of valves at entrance of great arteries to heart. 6. Pulse—what, where. 7, 8. Bleeding from arteries distinguished; cut artery; stopping bleeding. 9, 10. Capillaries—location, size, number, structure, function. 11. Circulation in frog's foot. 12. Blood changed in capillaries—arterial to venous, cause. 13–16. Veins—structure, peculiarities, valves, number of veins, location, functions, quantity of venous blood, color. 17. Current in veins—continued by pressure, suction, etc. 18. Veins unite; vena cavæ. 19, 20. Vaso-motor nerves—functions, distribution, result of cutting, relation to central nervous system, nerve-stimulus—pallor, blushing. 21–24. Animal heat, necessity for maintenance, regularity, local production, amounts generated in parts of body; regulation of bodily temperature—degree to be maintained; 1. agencies of regulation.

CHAP. XII. — 1. Quantity and quality of blood necessary to health—agencies. 2. Effects of poor or insufficient food, impure air, etc., on blood. 3, 4. Effect of pressure of improper clothing on blood-vessels and circulation—neck, extremities. 5. Proper distribution of blood in body—agencies; congestion relieved. 6. Mental excitement related to heart-trouble. 7. Intelligent care by patient in heart-disease; fatty degeneration; enlargement, aneurism—avoiding excitement. 8. Effects of alcohol on corpuscles; on oxidation and interchange; on bodily temperature. 9, 10. Alcoholic impoverishment of blood—manifest in heart, lungs, etc.; coagulation in blood-vessels; undue fluidity; wounds in habitual drinkers—danger of surgical operations. 11. Alcohol, the heart, and blood-vessels—paralysis of nerves, relaxation, congestion, undue rapidity of blood, “wear and tear,” reaction and exhaustion following stimulation. 12. Alcohol and structure of heart—weakness, fatty degeneration, rupture. 13. Effects of alcohol elsewhere in system. 14. Tobacco—effects on nerves of heart; heart disease, unduly fluid blood, etc.

THE RESPIRATORY, OR BREATHING SYSTEM.

CHAPTER XIII.

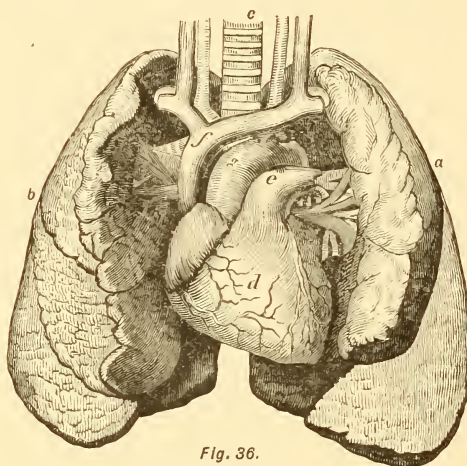
THE RESPIRATORY ORGANS.

1. **Why We Breathe.** — Whirled along by the current of the circulation, the blood, charged with nutritive matter, enters the heart and is thence propelled into all the organs of the body and supplies to them the nutriment which they need; from them it takes their waste products, and returns by the veins loaded with injurious or useless matter in the form of carbonic acid, water, and urea. These refuse matters are separated from the blood by the excretory organs; viz., the *lungs*, the *skin*, the *kidneys*. Each of these organs is especially employed in casting out one of the waste products; thus the *lungs* are concerned principally in eliminating carbonic acid; yet at the same time they give off considerable watery vapor.

2. But the lungs perform a double part. Not only do they eliminate waste products, but they effect an interchange of gases between the air which they draw in and the blood, — the air giving up to the blood *oxygen*, without which life could not be sustained, and receiving from it other gases, etc., unfit to support life. It is necessary

that we should take into our systems atmospheric air in order to obtain oxygen, a substance which, though not exactly food or drink, is as important as either. As the carbonic acid and water are passing from the blood through the lungs into the outer air, oxygen is passing from the air through the lungs into the blood and is carried by it to all parts of the body.

3. *Respiration* is therefore a process by which the oxygen of the air is introduced into the blood, and by



EXPLANATION.

- a*, the left lung.
- b*, the right lung.
- c*, the windpipe.
- d*, the heart.
- e*, the great artery carrying blood to the lungs.
- f*, the great vein.
- g*, the great artery carrying blood to the body.

Fig. 36.

which part of the useless and injurious materials are expelled in gaseous form. The drawing in of the air is called *inspiration*; the forcing out of the air, which has become changed during its stay in the lungs, is called *expiration*—the two functions are together known as *respiration*, or breathing.

4. **The Organs of Respiration.** — The respiratory organs are those that are essential to breathing. They are located

in the neck and cavity of the chest, and consist of the *larynx*, *trachea*, *bronchial tubes*, and *lungs*. The passages of the nose and mouth may be regarded as the outer openings of the respiratory apparatus; and the muscles of the ribs and the muscular *diaphragm*, which forms the floor of the chest, as furnishing the motive power.

5. Through the action of these organs atmospheric air is carried into the lungs where the oxygen it contains passes through a thin membrane and mixes with the impure blood carried to the lungs from the right side of the heart. As the oxygen enters the blood, carbonic acid and watery vapor, which are products of the waste or decomposition going on in the tissues, are cast out and expelled from the lungs. The following is a brief description of the organs of breathing and of the functions of each:—

6. The *larynx* (Gr., a whistle), sometimes called the *voice box*, because it contains the “cords” or membranes by means of which the voice is produced, is the enlarged, upper part of the air passage leading from the base of the tongue to the lungs. It is

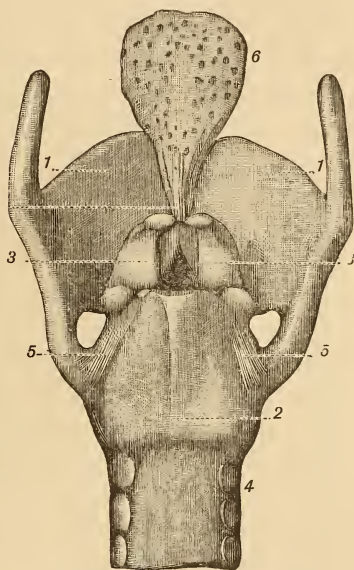


Fig. 37. Back view of the Larynx.

EXPLANATION.

1, thyroid; 2, cricoid; 3, arytenoid cartilages; 4, upper ring of the trachea; 5, ligaments; 6, epiglottis.

composed of cartilages connected by ligaments, and has attached to it numerous muscles which are concerned in producing sounds. The prominent projection in the front and upper part of the neck, commonly known as "Adam's apple," is formed by a part of the larynx. The opening leading into the larynx from the cavity back of the mouth (the *pharynx*) is called the *glottis* (Gr., *glotta*, the tongue). It is covered by a lid or valve of cartilage, called the epiglottis (Gr., *epi*, upon; and *glotta*, the tongue). During breathing, speaking, etc., the glottis is open; but during the act of swallowing it is closed by the epiglottis, thus preventing any solid or liquid matter from entering the wind pipe. Sometimes, while eating, a particle of food enters this opening, and, by irritation, causes a severe paroxysm of coughing, and even strangulation if the intruding mass is sufficiently large.

7. The *trachea* (Gr., *trachus*, rough) or *wind-pipe* is a cylindrical tube beginning at the lower part of the larynx, and, extending downward about four inches and a half, it divides and sends a branch to each lung. It is situated just in front of the food tube (*œsophagus*), and is that hard, rough tube which may be felt in the front part of the throat. Its walls are composed of soft, fibrous membrane, and are strengthened by a series of cartilaginous hoops which are incomplete behind, their ends being united by muscle and membrane where the trachea comes in contact with the food tube. It and its branches are all lined internally by a delicate mucous membrane, the surface of which is formed of a layer of cells covered with minute hair-like projections called *cilia* (Lat. *cilium*, an eyelash). These cilia have a constant fan-like motion which tends to drive toward the mouth any foreign mat-

ter which may come in contact with the lining of the air passages. In this way the lungs are kept comparatively free from particles of dust inhaled with the air breathed; and when phlegm discharged from the mucous membrane during inflammation accumulates in the air passages, it is in like manner urged towards the larynx, from which it is ejected by coughing. This provision is a protection against the constant danger of suffocation arising from the accumulation of matter in the air passages.

8. The *bronchi* are the two branches of the trachea. One of these (the *right bronchus*) leads into the right lung, and the other (the *left bronchus*) into the left lung. The right bronchus is larger than the left, the right lung also being larger than the left. These tubes divide and subdivide in the substance of the lungs till their tiny branches penetrate every part of those organs and terminate in very minute sacs, called *air-cells*. As the tubes diminish in size, the rings of cartilage which are found in all the larger branches become smaller and at last disappear, the walls of the smallest tubes being entirely muscular or membranous. It will thus be seen that, while the trachea and bronchi are kept permanently open by their cartilages, the smallest tubes may be almost closed by the contraction of their muscular walls.

9. The *lungs*, the principal organs of respiration (together with the heart and large blood-vessels), occupy and nearly fill the cavity of the *thorax* or chest, and consequently their general form coincides with that of this cavity. They are two in number, one situated in the right and the other in the left side of the chest, being separated by a space which is occupied by the heart and large blood-vessels. They are spongy, elastic sacks con-

sisting of air-tubes and cells, blood-vessels, and elastic tissue. In form they are conical, the apex being upward; and they are covered by a membrane, called the *pleura*,¹ which also lines the chest. One layer of this membrane

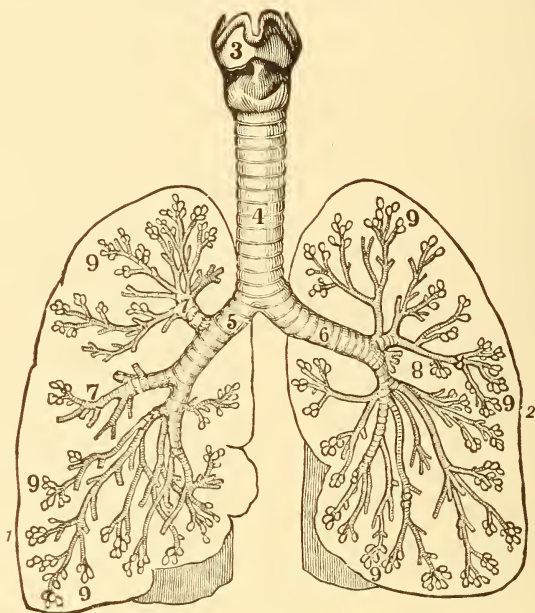


Fig. 38. The Lungs in outline, showing relation of larynx, trachea, bronchial tubes, and air-cells.

EXPLANATION.

1, an outline of the *right lung*, and 2, of the *left lung*; 3, the *larynx*; 4, the *trachea*; 5, the *right bronchus*; 6, the *left bronchus*; 7, 8, *bronchial tubes* of the *right* and *left lung*; 9, *air-cells* at the terminations of the *tubes*.

is so closely attached to the lungs that it can be separated only with difficulty; while the other is reflected back, so as to form a sac or bag, and is firmly attached to the walls of the chest.

¹ This membrane is often the seat of an inflammation to which the name *pleurisy* is given.

10. The lungs are divided, by deep depressions, into *lobes*, the right into three and the left into two, and these are divided again by smaller depressions into *lobules*. Each lobule is a miniature representation of the whole lung; a bronchial twig and a minute artery run into it, and veins and other vessels leave it.

11. The dark *venous* blood is forced from the right ventricle of the heart, through the pulmonary arteries, into the lungs. These arteries divide and subdivide into very small branches which penetrate every portion of the lungs, till finally they form fine networks (*capillary networks*) which surround and lie on the walls of the air-cells. The extreme thinness of the walls of the air-cells and of the minute blood-vessels brings the blood almost in contact with the inspired air in the cells. However thin these membranes may be, they are capable to confine the air and the blood in separate cavities; but they have also the property of allowing themselves to be penetrated by certain gases. The oxygen of the air therefore passes through them in order to combine with the blood; while those gases contained in this fluid, and which should be cast out, separate from it, pass through the walls of the cells, and mingle with the air, which carries them out with it during expiration. By exchanging carbonic acid gas for oxygen gas, the venous blood loses its dark color, and becomes converted into bright red arterial blood. Thus changed, the blood is conveyed by the *pulmonary veins* (Lat. *pulmo*, a lung) to the *left auricle* of the heart.

12. **Action of Respiration, or How We Breathe.** — The thorax, or chest, may be regarded as a completely closed conical box having the apex directed upwards; the back of box consisting of the spinal column, the sides formed of the

ribs, the front by the breast-bone, the bottom by the *diaphragm* (the broad muscle which separates the chest from the abdomen), and the top by the base or root of the neck,—the whole completed by the thin walls of muscle or flesh which unite them. Thus the chest-cavity is itself a closed cavity not in communication with the external air, but enclosing the lungs which admit air through the windpipe; the cavity is, however, capable of being enlarged by means of muscles which act upon its movable walls.

13. In order that the process of changing venous into arterial blood may continue, the air in the cells of the lungs must be frequently renewed. To accomplish this, the external layer of muscles between the ribs (the *intercostal* muscles, Lat. *costa*, a rib) contract and raise the ribs and breast-bone, thus making the chest-cavity wider from side to side, and from front to back; at the same time the diaphragm contracts and sinks down, pushing the abdominal organs downward, thus increasing the depth of the chest from the neck downwards. In this way the chest-cavity is made larger in all directions by the contraction of these muscles; and the tendency is to produce a vacuum. As the external air cannot go directly into the chest-cavity itself, it presses through the air-passages of the nose or mouth and thence through the windpipe into the lungs, distends the little elastic air-cells, and expands the lungs, so that they fill the enlarged space in the chest. Thus a certain amount of fresh air is added to that already contained in the lungs, and this process is called *inspiration*. As soon as this has occurred, the muscles in question relax, the diaphragm ascends, and other muscles lower the ribs and breast-bone and thus

diminish the cavity ; the lungs and air-cells collapse under the pressure of the walls of the chest, and by their own elasticity, and a portion of the air contained in them is forced out through the air-passages into the outer air. This latter process is called *expiration*.

14. " It thus appears that the thorax, the lungs, and the trachea constitute a sort of bellows without a valve, in which the thorax and the lungs represent the body of the bellows, while the trachea is the pipe ; and the effect of the respiratory movements is just the same as the approximation and the separation of the handles of the bellows which drive out and draw in the air through the pipe. There is, however, one difference between the bellows and the respiratory apparatus, of great importance in the theory of respiration, though frequently overlooked ; and that is, that the sides of the bellows can be brought close together so as to force out all, or nearly all, the air which they contain ; while the walls of the chest, when approximated as much as possible, still enclose a very considerable cavity ; so that, even after the most violent expiratory effort, a very large quantity of air is still left in the lungs." And this brings us to a consideration of the capacity of the lungs and of —

15. **Tidal Air, Supplemental Air, Residual Air, and Complementary Air.** — The air which passes in and out of the lungs in ordinary, quiet breathing is conveniently called *tidal air*, and amounts to from twenty to thirty cubic inches in the adult person.

16. About 200 cubic inches of stationary air remain in the lungs after each ordinary *expiration* ; but by making a very deep expiration about 100 cubic inches of this can be expelled, and this is called *supplemental air*.

17. The amount of air which remains and cannot be expelled is about 100 cubic inches, and is termed *residual air*.

18. From the foregoing statements it follows that, after an ordinary inspiration, the lungs contain 230 cubic inches of air. By making the deepest possible inspiratory effort, another 100 cubic inches may be added, and this is significantly called *complemental air*.

19. It further follows that the fresh, inspired air cannot directly reach the air-cells at all. The supplemental and the residual air, taken together, are, under ordinary circumstances, stationary; the *tidal* air alone being that which leaves the lungs and is renewed in ordinary breathing. Hence it becomes evident that the exchange of carbonic acid for oxygen is chiefly transacted by the stationary air, which assumes the part of an agent between the blood and the fresh, tidal air; but as there is nothing interposed between the fresh tidal air and the stationary air in the lungs, and as both are aeriform fluids in contact and continuous, they must effect the exchange between them according to the ordinary laws which govern the diffusion or intermingling of gases, though the exact mode in which the change is effected is not fully understood.

20. **Difference between Inspired and Expired Air.** — The extent to which changes take place in the body may be understood by comparing expired with inspired air. The expired air differs from the air inspired in the following particulars: —

(a) Ordinarily, inspired air contains 21 parts of oxygen, about 79 parts of nitrogen, and not less than .04 parts of carbonic acid; while expired air contains about 5 parts *more* carbonic acid gas and 5 parts *less* oxygen, the quantity of nitrogen remaining about the same.

(*b*) Whatever the temperature of the external air, that of the expired air is nearly as warm as the blood, or between 98° and 100° .

(*c*) No matter how dry the external air may be, that expired contains a large amount of watery vapor, being nearly or quite saturated.

21. Rapidity and Amount of Respiration. — An adult at rest breathes about fifteen times a minute. Children breathe much more rapidly than adults; and the circulation of the blood in children is correspondingly more rapid.

22. From statements already made, it will be easy to calculate the quantity of air inspired and expired in a given time. In twenty-four hours this would amount to between three hundred and seventy-five (375) and four hundred (400) cubic feet of air passed through the lungs of an adult man, taking little or no exercise. In other words, this amounts to about eighteen cubic feet of oxygen taken in, and an equal quantity of carbonic acid gas given out, in the time mentioned. Shut up in a close room having the form of a cube whose sides are seven feet, a man will have passed through his lungs every particle of air of that room, and one-fourth of the oxygen it contained will be replaced by carbonic acid gas.¹ In such an instance, when one or two per cent of the oxygen had been consumed, a feeling of general uneasiness accompanied by giddiness or headache would arise. As the loss of oxygen increased, there would not be sufficient of it in the inspired air to change the color of the blood;

¹ The quantity of water given off in the breath from the lungs in twenty-four hours varies greatly, but the average amount may be placed at about a half-pint, equal to about nine ounces. It may fall below this amount, or increase to two or three times the quantity.

and this would certainly be the fact when the loss of oxygen and the gain of carbonic acid gas rose to ten per cent. In consequence, the blood would be *venous* throughout the system; carbonic acid gas, which is slightly poisonous, would accumulate in the blood, and this together with the oxygen starvation (more particularly the latter¹) would quickly cause death from *asphyxia* (Gr. *a*, without; and *sphuzio*, I throb), a stoppage of the circulation of pulse, caused by suffocation. In choking, strangling, or drowning, asphyxia ensues from the fact that oxygen cannot enter the blood, while the latter soon becomes saturated by the rapidly accumulating carbonic acid gas.²

23. From the foregoing, necessity for providing means for the removal from rooms of the expired air, and for the access of pure air, will be understood.

24. **Diaphragmatic and Costal Breathing.** — In tranquil breathing, the inspiration of air is effected principally by the *diaphragm* in men, while in forced inspiration, or after rapid exercise, the intercostal muscles are brought into play in moving the ribs. In women, on the contrary, the *diaphragm* does not perform so important a part as the ribs. Thus it appears that we may have either *diaphragmatic respiration* or *costal respiration*. As a rule, however, the two forms of breathing coincide and aid one another.

¹ In such case death would probably be caused by the deprivation of oxygen rather than by the poisonous effects of carbonic acid gas, it having been proved by experiment that air containing ten or fifteen per cent of this gas produces no immediate effect on the system if the supply of oxygen be proportionately increased.

² Conversely, the breathing of an atmosphere too highly oxygenized produces changes in the respiratory process, causing it to cease in time; the blood becomes too much arterialized; and the balance being destroyed, the apparatus ceases to act. Various drugs or medicines produce similar derangements. Ammonia stimulates the centres. Belladonna first stimulates then paralyzes. Opium, ether, chloral, and many other drugs also have a paralyzing effect.

25. Persons who breathe chiefly by means of the upper ribs are easily fatigued and very soon "out of breath." This is apparent in women when the corset compresses the base of the chest and interferes with and impedes the action of the diaphragm and lower ribs ; under such conditions the efforts of the inspiratory muscles become painful, fatigue is rapidly induced, and the inspiration becomes more frequent because it is always incomplete and insufficient.

26. "Deep breathing, using the diaphragm and the abdominal muscles, of which the majority of women have no knowledge, gives the most efficient exercise to the digestive tract. The 'A, B, C' of health lessons is in deep, natural respiration. The lungs must be filled to the bottom. The most eminent vocal instructor in this country asserts that 'the main action should be at the waist and below the waist.' Animals and children have this natural breathing. Men and women lose it from lack of exercise and constriction of dress." Health, strength, power of endurance, and length of life depend very greatly upon lung capacity.

27. Diaphragmatic breathing is practised by mountain-climbers, gymnasts, and skilful singers, the habit being induced either by instinct or by a well-directed education.

28. **Respiratory Sounds or Murmurs.**—As elsewhere remarked, there are certain secondary phenomena which accompany and are accounted for by the action of the heart ; so also there are similar phenomena which accompany the action of the respiratory apparatus. These are the respiratory sounds, and are audible when the ear is applied to any part of the chest which covers the lungs. They resemble the sounds produced by breathing through

the mouth when the lips are very nearly closed, and are louder at the upper part of the chest, over the bronchi, than elsewhere. It appears that these sounds are produced by the air in its movements through the air-passages.

29. When a person is in a normal condition and awake, breathing takes place without exterior sound if the movement is moderate. If, however, respiration is strong and deep, a sound is caused by the movement of the air through the passages of the nose, or through the mouth. Snoring is caused during sleep when the entering column of air breaks upon the soft palate.

30. On applying the ear to the chest of a person in good health, a soft, regular murmur is heard in rhythm with the breathing. Several diseased conditions cause changes in the nature of this murmur, suppress it, or produce other sounds which act as signs to the physician, enabling him to determine the condition of the organs of respiration.

31. **Respiration influenced by Atmospheric Pressure.**—The density of the air diminishes with the atmospheric pressure; that is, the air is less dense in elevated regions than in lower ones, on the seacoast for example. A given quantity of dense air contains more oxygen than an equal quantity of rarefied air. Hence it is that in order to supply the lungs with the quantity of oxygen essential to arterialize the blood, it is necessary to respire more rapidly upon high mountains than when breathing the air of plains or valleys. It is, however, only when the height is considerable and the ascent is rapidly made that this increased rapidity of breathing is perceptible.¹

¹ In balloon ascensions made to the height of more than 20,000 feet (that of Guy

32. The exertion of walking in climbing mountains increases the disturbance caused by the rarity of the air ; but, when in a single day an altitude of sixty-five hundred feet is reached, a very perceptible hastening of respiration and the pulse is experienced, in many instances accompanied by peculiar disturbances which have been called *mountain sickness*, the most remarkable symptoms of which are fatigue or partial paralysis of the muscular system, especially of the muscles of the legs. The higher the ascent the shorter the distance that can be passed without resting. Inclination to sleep, weakened action of the heart, and loss of animal spirit sometimes accompany the general exhaustion. In some cases mountain sickness closely resembles sea-sickness.

33. The adaptability of the human organism is such, however, that man has easily acclimated himself to the rarefied air of immense heights, and suffers no inconvenience from it ;¹ and it may be added that the difficulties of respiration are not equally experienced by all who enter a rarefied atmosphere. Some persons are but little disturbed, and soon become accustomed to the change, while others suffer for a long period of time. This brings us to the consideration of air in general, of its effects when it is impure, and of the necessity for its renewal when contaminated in order to maintain healthy existence.

Lussac, for instance), requiring only a few hours, respiration is disturbed and greatly hastened ; and as no physical exertion was required, this condition could only be attributed to the diminished atmospheric pressure.

¹ In Peru land is cultivated at an altitude of 13,450 feet above the level of the sea. La Paz is located in the Andes at a height of 12,195 feet, while in Thibet there are villages at an elevation of 16,400 feet.

CHAPTER XIV.

THE AIR WE BREATHE.

1. **The Atmosphere.**—The earth is surrounded by an envelope of air commonly called *the atmosphere*. Estimates or opinions vary greatly in regard to the thickness of this covering of air; but as regards the necessity of pure air as a condition essential to healthy existence, all will agree. It has been remarked elsewhere that, without food, life may still be prolonged for days; without air, on the contrary, life becomes extinct almost instantly. When air is impure its effects may be traced throughout the entire system; and many diseases are due either to its impurity as a whole, or to the germs of disease which impure air is known to contain and distribute.

2. Pure air consists of a mixture (*not* a chemical combination) of two gases, *oxygen* and *nitrogen*, together with varying proportions of *carbonic acid*, *watery vapor*, and *other matters*. While the oxygen and nitrogen are essential constituents of the atmosphere, the other matters although rarely, probably never, entirely absent from air even when it is pure, may be regarded as accidental components which are liable to be so increased, under certain circumstances, as to be highly injurious to animal life.

It has already been roughly stated that air is composed of twenty-one parts of oxygen and seventy-nine parts of nitrogen. A more exact statement of air composition may be made as follows:—

In one hundred parts of pure air there are —

Oxygen	20.99 parts.
Nitrogen	78.97 “
Carbonic acid04 “
Watery vapor	} traces.
Ozone	
Ammonia	

3. *Oxygen*, the most active of the gases essential to the composition of air, has been mentioned frequently, and its offices in respiration have been stated in the preceding chapter. It is an invisible gas which powerfully supports combustion or burning, but is not itself combustible. Oxygen forms about one-fifth of the volume of the atmosphere, and is that element of the air which supports combustion and animal life. It also forms eight-ninths of the weight of water, and is so abundant in the earth's crust that it is estimated to form more than one-third of the weight of the globe. Oxygen is, in fact, the *vital principle of the atmosphere*; and without it, combustion and life would both be impossible.

4. *Nitrogen* is a very inactive gas, so far as animal life is concerned. Its office in the atmosphere is to dilute the oxygen and modify its action, being mixed with the latter gas in proportions which render the air breathable and fit to sustain animal life. Nitrogen appears to pass in and out of the lungs unchanged; and little, if any, of this gas is absorbed into the blood.

5. **The Accidental Components of Air.** — The chief of the gases spoken of as accidental, or not essential to the air, is *carbonic acid gas*. Whenever the apparently trifling quantity present in pure air is slightly increased, impurity of the air results. It is this gas, as we have learned,

which is given off from the lungs as a waste product. The substances commonly used for lighting and warming rooms contain carbon and hydrogen as their chief constituents; and when they are burned, carbonic acid gas and watery vapor are given off and increase the quantity of these in the air. When the burning is not complete, particles of carbon¹ (soot) escape unburned into the air.²

6. It may be of interest to note that, since animals are continually consuming oxygen from the air by respiration, it must be replaced, and that this is done by plants. Green plants in the daytime or in the presence of light, absorb carbonic acid from the air and decompose it into oxygen and carbon, retain the carbon for food, and give off the oxygen into the air. Flowers of plants and ripening fruits, however, absorb oxygen, and give out carbonic acid. Plants which, like the fungi, are not green, habitually absorb oxygen and send out carbonic acid.³ It will thus be seen that carbonic acid gas in excess of the normal amount constitutes one of the chief causes of impurity of atmosphere in and about the habitations of men.

7. *The watery vapor* contained in the atmosphere varies

¹ Carbon is a solid element which exists in a variety of forms. As a natural mineral substance we are familiar with it as graphite (plumbago or black-lead), hard-coal, and the diamond, the latter being its purest crystalline form. Charcoal, lamp-black, and soot are artificial forms of carbon.

² Partially burned fats under some circumstances give off an acrid and very poisonous compound called *carbonic oxide*; and thus when these substances are not perfectly burned the air is rendered much more impure than when they are thoroughly burned and produce carbonic acid and watery vapor.

³ Green plants, however, even in the light, absorb small quantities of oxygen, and give off a small amount of carbonic acid gas, these processes constituting *respiration* whether in plants or in animals.

greatly in quantity, the higher the temperature of the air the more water it can contain, and *vice versa*. It is only very rarely that the atmosphere is saturated with watery vapor, there being present usually only from one-half to three-fourths of the quantity required for complete saturation. Air expired from the lungs, on the contrary, is saturated with watery vapor which represents so much waste material. It has been estimated that from nine to ten ounces of water are given off by the lungs of an adult in twenty-four hours.

8. *Ammonia* exists only in the slightest traces in pure air. In air expired from the lungs the quantity of ammonia is very small, while the organic matter given out has been estimated at about three grains in twenty-four hours.

9. *Ozone* (Gr. smell or odor), so called because it has a peculiar odor, is an altered and condensed form of oxygen. It is a powerful disinfectant and deodorizer, and it rapidly consumes and destroys foul organic matters with which it comes in contact. This gas is contained in sea-air and in mountain-air, and is present in air during thunder-storms and during a fall of snow. It is never found in tainted air, and its presence is regarded as a proof of the purity of air.

10. **Dust.** — In addition to the deleterious gases which the air is liable to contain, especially wherever human beings are crowded together, certain solid particles are suspended in the air as dust. These minute particles are readily seen dancing as “motes” in the track of a sun-beam. They consist very largely of mineral matters derived from the soil. Included among these particles are

found dead organic matter,¹ as the scales of the scarf-skin ; the fibres of clothing, or of cotton and wool ; vegetable dusts of various kinds, as the pollen of plants, the spores of fungi, etc. The air in and near large towns contains soot produced in the burning of substances (especially of coal) used in warming and in manufacturing. In many manufacturing operations dust is produced and becomes diffused in the air. The breathing of air containing much dust of any kind causes irritation of the respiratory organs ; and from the fact that small particles get into the lungs and set up irritation there, lung diseases of various kinds, including consumption, are prevalent amongst those who are exposed to such air.

11. Breathing should, as a rule, be conducted through the passages of the nose ; the mouth should be employed in breathing only when the nasal passages are so obstructed as to render them inadequate for the purpose, or when for other reasons mouth-breathing becomes absolutely necessary. Air breathed through the nose travels farther over warm surfaces of the air-passages, and hence its temperature is more agreeable to the lungs than when inhaled by the mouth. Particles of dust are, moreover, more fully arrested and less liable to get into the lungs when breathing takes place through the nose. It is best, therefore, to regard the nasal passages as being designed for the ordinary purposes of respiration, and the mouth as intended to be so employed only in cases of necessity.

12. The use of a very simple "respirator" containing a small quantity of cotton-wool, through which the inspired

¹ Organic substances (animal and vegetable substances) are subject to decay, a chemical change by which they are decomposed into gases which pass off into the air. *Organic matters* here meant are the worn-out particles of the body.

air might be filtered and the dust prevented from entering the air-passages and lungs, would undoubtedly very much decrease the death-rate from bronchitis and consumption among those who work in dust-laden atmospheres.

13. Bacilli. — The air also carries and distributes many of the lower forms of life, among which are the “germs” of various diseases. When breathed or otherwise received into the human system, these germs or *bacilli* produce, under certain favorable conditions, the diseases from which they originate. For instance, it has been proved that consumption develops a special germ or *bacillus* in the tissues of the lungs, and that these bacilli, which are microscopic in size, are exhaled from the lungs of consumptive patients in breathing. Their presence in the air of the wards of hospitals for consumptives has been demonstrated by experiment. And thus it is in regard to the bacilli of yellow fever, typhoid fever, cholera, etc., the presence of actual disease-particles in the air being no longer a matter of mere theory, but one of absolute certainty and proof. *Disinfection* of the air, or the process by which certain fluids are diffused so as to fill the atmosphere with their active principles, is simply a work of destroying the germs, or lower forms of life, which air is known to contain. There is little doubt that epidemic diseases are spread by a diffusion of their bacilli in the air which carries them.

14. Many bitter experiences of disease and death resulting from tainted air should prove more than sufficient to impress the truth that fresh air, like pure water, is imperatively necessary for health.

CHAPTER XV.

VENTILATION AND THE REMOVAL OF WASTE MATTERS.

1. **Object of Ventilation.** — A constant supply of fresh air is in the highest degree essential to health. Without it, as we have seen, the lungs cannot supply to the blood the oxygen necessary for its purification, and all the tissues of the body suffer in consequence. In short, pure atmospheric air is an absolute necessity for perfect nutrition, and all available means of obtaining it should be adopted in every house, private and public.

2. In densely inhabited cities, and in occupied rooms, the atmosphere is never found in its natural purity. Smoke, dust, and gases from factories of various kinds, tend to contaminate the air. The germs from decomposing animal and vegetable substances when not removed also add largely to its impurity and become causes of disease.

3. In rooms into which the outer air does not have free ingress, the oxygen is soon more or less exhausted even by one or two persons. Lights and fires when employed in such rooms exhaust the oxygen still more rapidly. The air becomes loaded with exhalations from the skin, and over-charged with carbonic acid gas given off by the lungs. Unless fresh air is admitted, the vitiated air must be breathed again ; and it then not only fails to supply the oxygen required, but it poisons the body by carrying back impurities into the blood.

4. The object of ventilation is a twofold one. It is desirable to provide for the removal of the foul air, and to secure a sufficient supply of pure air, effecting the interchange in such a manner that there shall be no draughts or the exposure of the occupants of the room to cold or undue temperature.

5. When scientifically applied, ventilation involves calculations regarding the amounts of air needed and the frequency of its renewal in order to insure its purity, and considerations relative to the best means of securing its entrance and exit. Ventilation is a complex subject, and the difficulty of applying or adapting effective methods to the existing architecture of our houses no doubt accounts for the fact that it has been so extensively neglected.

6. **Ventilation Ignored in the Construction of Dwellings.** — “As our houses are ordinarily built, the question of ventilation is practically ignored by architects. For light, for water-supply, and for warming, provision is made; but to the renewal of air no consideration is given. Each room is practically an air-tight box, depending for ventilation, when the windows are closed, on mere chance — on the fireplace and chimney, on the crevices of the doors and windows, and on the space which may exist between the door and the flooring. In the higher era of sanitation to which we are advancing, the ventilation of a house will form as important a consideration in the minds and practice of architects as the size of the rooms and the cost of materials. In ancient times, ventilation formed a topic which received considerable attention. The Chinese have long made the subject a study; and in classic times, the Greeks and Romans used fans and fires as means of ventilating their domiciles. Even in the bee-hive, ventilation

is practically carried out by the flapping of the insects' wings ; and the modification of nature's ways and means to the wants of animal life is thus illustrated in a thoroughly practical fashion."

7. **Principles and Means of Ventilation.** — In the ventilation of rooms and apartments the currents of the atmosphere may be utilized ; fires may be so employed as to increase the strength of air-currents ; or mechanical means, such as fans, pumps, propellers, etc., may be employed to set the air in motion. It is not practicable, and is not our purpose, to describe here the more technical kinds of ventilating apparatus ; but it is important that consideration be given to the means which may be employed conveniently in ordinary houses and under ordinary conditions.

8. The *mechanical or artificial means of ventilating* by fans, or other apparatus, are highly useful and, in fact, indispensable in manufactories and other large buildings in which it becomes necessary to provide for the rapid removal of dust and other impurities.

9. For successful ventilation the air taken must be pure (not received from other apartments or contaminated sources), and must pass continually into the room, sufficient provision being made for the exit of the impure air. The entering air must not be so directed as to cause a draught, but should be distributed equally, as far as possible, to all parts of the room.

10. We now proceed to consider what is called *natural ventilation*, in which the process is carried on by means of the *wind* and by means of *variations in the weight of the air due to differences in its temperature*, without apparatus to produce currents.

11. Natural Agents of Ventilation. — First, the *wind* is a powerful agent of ventilation. Even a gentle breeze, one moving not more than a mile an hour, will change the air of a building thoroughly if the windows are open on both sides of it, and are in the line of direction, or nearly so, in which the breeze is moving. But the irregularity of the wind makes it unreliable as a ventilating agent ; although seldom perfectly motionless, at times it moves too rapidly to be employed satisfactorily, especially in cold weather. In warm weather, contrivances are not required ordinarily to secure ventilation. The windows and doors being opened, the air of the house is changed rapidly unless the outer air happens to be quite motionless.

12. Probably the most important and reliable agent that can be utilized in natural ventilation is found in the movements produced in the air by variations in its weight caused by differences in its temperature. Assuming that the air outside is cold, as in winter, and that the air of rooms is warmed by radiation from the bodies of human beings and sometimes by fires, the cold air outside, being heavier and exerting a greater pressure than the warm air inside the room, *will force its way in through any opening that is provided*. Bearing this principle in mind, we proceed to consider some of the simple methods of ventilating rooms and dwellings.

13. Methods of Ventilation. — The principal points to be considered are, firstly, the positions of the air-inlets and air-outlets. Fresh air should not be allowed to enter near the level of floor, as draughts would be thus caused, and dust and other injurious matter would be liable to be carried from the floor into the air of the room. Secondly, the openings for the entrance of air should be *above the*

level of the heads of occupants of the rooms ; and it is important that the in-flowing air should be directed upwards to the ceiling and caused to descend gradually, diffusing itself through the air of the room and making its composition uniform. For if an opening is made directly through the wall of a room above the heads of the occupants, as in lowering the upper sash, the cold air will pour in and fall down in a stream at a short distance from the opening, and therefore the necessity for giving it an upward direction. It should take the form of a fountain, not that of a cascade. The entering current may be subdivided by means of numerous small apertures or perforations, or by conical openings (the large end of the opening being next the room) which tend to disperse the entering air.

14. A simple method of ventilation by means of windows is as follows : If an ordinary sash window is opened at the bottom, the air enters too low, and is not directed upward ; while if it is opened at the top, entering air pours down upon the heads of those in the room. However, by raising the bottom sash and inserting beneath it a strip of board which shall extend from side to side, the top of the lower sash is raised above the bottom of the upper sash to an extent equal to the depth of the board. In this way the two sashes are separated, and the air entering between them is directed upward by the top part of the lower sash. This simple plan is of value in ventilating rooms to which other methods cannot be applied, and is especially valuable in sleeping-rooms.¹

¹ " According to the laws which regulate the *expansion of gases*, air expands when heated, and contracts on cooling. Warm air, being lighter than cold air, ascends. As it passes upwards, it becomes cooled through contact with the walls, glass, etc., of the

Another simple expedient consists in cutting away a portion of the lower cross-piece of the upper sash, so that when the window is closed the air rises vertically into the room close to the window-panes of the upper sash. By placing in the openings narrow boxes (without top or bottom) filled with cotton-wool, the entering air may be filtered and soot and dust separated from it. Very fine gauze netting may be substituted for cotton-wool.

15. Windows swung on a pivot midway of their length, the upper half sloping inwards and the lower outwards, are very effective ventilators for closets and small rooms. For large rooms in which great numbers of people congregate, such as assembly rooms, churches, etc., and where immense quantities of fresh air should be supplied, the most suitable windows are composed of several sashes which slope forward into the room when they are opened, and give the entering air an upward direction.

16. A room may also be ventilated by making an opening through the wall to the outer air, high up, but not too near the ceiling. A board (provided with cheek-pieces at its ends) fastened against the wall below the opening and sloping inward and upward, will give the required upward direction to the air which enters. If the opening is located too near the ceiling, the entering air strikes the ceiling

room, and in consequence descends. Thus the colder air in a room will tend to force upwards the warm air, and the rapidity with which this interchange may take place will depend on the size and other conditions connected with the openings through which the air has to pass. It becomes clear, therefore, that wherever there exist openings through which the warm air in a room may be placed in communication with the colder outside air, an interchange must take place. The warm and lighter air inside passes out, and the colder and heavier atmosphere outside rushes forcibly inwards. Thus a system of natural movements of the air exists; and in the institution of ordinary non-mechanical ventilation these movements are not only utilized, but require, as a matter of fact, to be taken always into consideration."

and is deflected downward toward the opposite side of the room, thus causing a draught. For the purpose of intercepting dust, and to divide the entering air into a large number of small currents, wire gauze should be placed on the outer side of such openings. Such are a few of the most simple methods of natural ventilation. For others the student is referred to more elaborate treatises on ventilation.

17. The subject of *air-outlets* in connection with the foregoing and other methods of ventilation, is a difficult one. In dwelling-rooms, the chimney, if there be one, is regarded as affording a sufficient outlet for foul air. It is therefore well to bear in mind that, if reliance is to be placed on the chimney as an exit for impure air, the opening leading into it should never be closed. A valve¹ designed to serve as an exit for impure air may be placed in the wall near the ceiling, and open into the chimney. This light metal valve is so adapted that it swings toward the chimney-flue when the pressure of air from the room into the flue is sufficient; but when the pressure from the chimney into the room is the more powerful, the valve closes and prevents the ingress of smoke or air.

A more effective plan is to have a separate tube or shaft, divided longitudinally from top to bottom by a partition, and having openings from each of its sections into each room, near the ceiling, the shaft to extend beside the chimney and terminate above the roof. *If the doors and windows are kept closed*, a current of the outer air descends into the rooms continuously on one side of partition, and a current of impure air ascends from the room continuously on the other side of the partition. If the tube be of proper size the air in the room is kept pure.

18. Artificial Ventilation. — In many instances, as in large, crowded buildings, none of the methods of natural ventilation are sufficient to provide a constant supply of fresh air, and it therefore becomes necessary to employ what is known as *artificial ventilation*, in which air is forced in and out by apparatus driven by steam or electricity. Of the methods employed in artificial ventilation, the most common are those by *propulsion* and by *aspiration*. By the former method, fresh air is driven into the building and foul air allowed to escape by shafts or flues; and by the latter, the impure air is drawn out of the building, and fresh air allowed to enter and take its place, after having been previously warmed, if required. In case revolving fans are used, they are caused to revolve at an immense rate by stationary engines, by electricity, or by other motive power; and by their employment air can, in one instance, be driven out of a building, or, on the contrary, may be forced into it through tubes. Such means are resorted to in various hospitals and other large buildings.

19. Quantity of Air Required. — Experiments have shown that whenever the carbonic acid gas in the air of occupied apartments exceeds that in the outer or pure air by 2 parts in 10,000 of air, the air of the apartments becomes unfitted for breathing. In other words, the amount of air-impurity which renders air unfit to be breathed is equivalent to .2 of a cubic foot in 1,000 cubic feet of air. As each person exhales, on an average, about .6 of a cubic foot of carbonic acid in an hour, it is evident that the air of a room containing 1,000 cubic feet must be diluted by the admission of three times the quantity of air, or 3,000 cubic feet, if the carbonic acid breathed out is to be reduced to proportions safe for continued breathing. As-

suming that each person is provided with 1,000 cubic feet of space, the air should be renewed three times per hour; with 750 cubic feet of space, the air should be changed four times per hour; with 600 cubic feet, every twelve minutes, and so on. The rapidity with which the air becomes impure is thus seen to be very great, the smaller the space the more rapid the contamination.

20. In the foregoing statements, the burning of lights has not been taken into account. It is estimated that an ordinary gas-burner, consuming three cubic feet of gas per hour, destroys the oxygen of twenty-four cubic feet of air and gives off six cubic feet of carbonic acid gas and other impurities. It will therefore be seen that the impoverishment and contamination of the air in lighting and heating rooms is a highly important consideration in view of the requirements of ventilation. Fortunately, the electric light removes one of the most prolific sources of air-impurity in rooms and dwellings.

21. Removal of Refuse Matters.—A chapter treating of ventilation and failing to consider the related topic of the removal of waste or refuse matters from the vicinity of habitations, would be manifestly incomplete. The maxim that "dirt is only matter in the wrong place," states an important truth; and the removal of this wrongly-placed matter is essential to healthy existence. A cleanly house, with wholesome surroundings, is as necessary to health as cleanliness of body. The removal and proper disposal of waste matters owes its importance to the fact that, when people are crowded together in large numbers, as in cities and large towns, refuse matters accumulate enormously, and become a menace to public health when they are not immediately and effectively disposed of by sewers or

otherwise. When improperly treated, refuse and foul matters are common sources of air-impurity and water pollution; and a large proportion of epidemic and other diseases is undoubtedly due to carelessness in the performance of the duty of removing waste matter, garbage, etc. Typhoid fever, cholera, diphtheria, and other deadly diseases, are caused and fostered by carelessness in the removal of decomposing animal and vegetable matter, and are found to disappear when such matter is carefully treated and promptly removed from the vicinity of human dwellings.

22. Cesspools. — The disposal of waste matters by means of pits, called *cesspools*, has always been seriously objectionable because the pollution of the water in wells is frequently caused by such accumulations. Not only is the cesspool a danger in itself when, as is often the fact, it is situated near the house; but some of its contents are liable to soak into the soil, and thus pollute wells. Numerous instances have been reported in which epidemics have been clearly traced to the drinking of water which had been polluted by the contents of cesspools.

23. Where such receptacles form the only convenient means of disposing of refuse matters, their construction should be intelligently and carefully supervised. The cesspool should be perfectly tight in order that its liquid contents shall not filter through its sides into the surrounding soil; and its bottom should slope decidedly toward one side in order that the contents may be readily removed, when necessary, by pump or siphon. A ventilator should be provided; and if a soil-pipe runs into the pool from the house, it should be ventilated, "trapped," and should not be connected with other drains from the

house. In fact, all drains leading from the house should be provided with effective "traps" to prevent the foul gases generated in the cesspool from being carried into the house. The agents of protection against sewer gas are efficient ventilation of house-drains and well-constructed "traps."

24. Unless absolutely unavoidable, no drain should be located under the basement of a house. Leakage from a disconnected or otherwise defective basement drain saturates the soil, and, by giving off foul gases, in time renders a house a hot-bed of disease. Whenever a drain beneath the basement becomes necessary, great care should be exercised in making it perfectly water-tight and air-tight. Finally, "definite arrangements for the periodical clearing and cleansing of the receptacle (the cesspool) should be included among the laws of the household."

25. Sewers. — The necessity for providing means of disposing of slops and other liquid refuse matters from houses and factories, in populous towns and cities, brought *sewers* into use. Sewers usually consist of stone-ware pipes leading into larger tunnels built of brick and cement, which convey and discharge the sewage matter into a river, into the sea, or into tanks. In the latter case various methods of utilizing the sewage for the enrichment of the soil have been devised.

26. In consequence of the offensive and dangerous nature of their contents, the proper ventilation of sewers and frequent flushings with water are imperatively necessary. The ventilation of sewers tends to lessen the danger of a backward flow of sewer gas into houses, through the house-drains. The usual method of ventilating sewers is by means of openings in the streets, covered by gratings.

If sewers are well constructed and kept clean, foul gases are not formed in considerable quantities; but if badly constructed and not kept clean, it is far better that the gases formed should escape into the open air than find their way into houses through the drain-pipes.

27. At the connection between the house drain-pipe and the main sewer, there is usually placed a water "trap," which, whatever its special shape, is essentially a bend or elbow in the pipe that will hold water, the water so held being intended to serve as a barrier against the passage of foul air from the sewer. Other traps are, or should be, placed beneath sinks, set wash-bowls, bath-tubs, etc., for the same purpose. Water-traps are, however, not to be relied on alone; they frequently form receptacles in which solid matter lodges and decomposes, and they usually contain foul water. Here again, personal care becomes an important factor; and unless the traps are frequently flushed with pure water and all solid matter removed, decomposition goes on in them continually and foul gases are produced, "so that they become manufactories of foul air."

28. It is very important to provide means of ventilation for the house-drain, and this is usually done by connecting a four-inch pipe with the drain (at the farthest point from the main sewer) and extending it up through the house, higher than the edge of the roof. In addition to this an inlet opening should be made in the drain between the house and the water-trap, through which a current of air can enter the drain-pipe and pass out at the roof.

29. Solid matters that cannot be disposed of by means of sewers are collected, and, if combustible, are burned in immense retorts, or are otherwise removed from the vicinity of human habitations.

30. In all contagious diseases, such as small-pox, diphtheria, scarlet fever, cholera, etc., slops and all other refuse matters should be disinfected, in order to destroy the *bacilli* or germs of the disease, before being cast into drains or otherwise removed. *Fumigation* of the room and *disinfection* of all its contents are equally necessary, and for the same reason.

31. Effects of Alcohol and Tobacco.—Alcohol, on entering the blood, absorbs water from the corpuscles and shrinks them, thus reducing their capacity as carriers of oxygen and carbonic acid, and diminishing oxidation and the prompt and complete elimination of waste products. In these ways the habitual use of alcoholic drink interferes with the purposes of respiration. Again, by its effects on the blood, blood-vessels, and nerves, it thickens the tissues of the lungs, thus causing obstruction of the circulation and *Congestion*. One fatal form of lung disease caused by alcohol is known as “rum consumption.” *Pneumonia* is most frequently incurable and fatal in persons addicted to alcoholic drink.

32. The smoke of tobacco contains many fine particles which are inhaled and lodge in the air-passages, creating irritation. In the smoking of cigarettes the smoke is usually inhaled, and the poisonous products of the combustion of tobacco are thus most readily and quickly absorbed into the system. As cigarettes are more likely to be used to excess than tobacco in other forms, they are most objectionable and injurious. Tobacco is injurious to the voice from irritation of the mucous lining of the throat.

Suggested Points for Questions.

CHAPTER XIII. — 1. Refuse matters separated from the blood — organs engaged; lungs' principal office. 2. Double office of lungs; oxygen vitally necessary — absorbed. 3. Respiration defined — inspiration, expiration. 4. Respiratory organs — location, names; motive power. 5. Interchange of oxygen and carbonic acid, etc. 6. Larynx — location, structure, vocal cords, Adam's apple; glottis, epiglottis — action of; strangulation from food. 7. Trachea — location, structure; mucous membrane — cilia and their functions. 8. Bronchi, comparative size, branches; air-cells; structure of smallest air-tubes — closure. 9. Lungs — location, form, separation; elastic nature, tissues, pleura. 10. Lobes of lungs; lobules and vessels. 11. Venous blood carried to lungs — pulmonary arteries and branches; capillaries and air-cells — nature; oxygen entering the blood, gases passing out; blood change; pulmonary veins — functions. 12. Thorax a closed box — structure; capable of enlargement. 13. Action of respiration — diaphragm, intercostal muscles; inspiration and expiration described. 14. The lungs a bellows; lungs never empty. 15. Tidal air — amount. 16. Stationary air — amount; supplemental air — amount. 17. Residual air — amount. 18. Ordinary quantity inspired; complemental air — amount. 19. Interchange effected by stationary air — explanation. 20. Difference between inspired and expired air — gases, temperature, moisture. 21. Rapidity of respiration. 22. Quantity of air respired in 24 hours — oxygen absorbed, carbonic gas given off; breathing in a close room whose dimensions are 7 feet — result; asphyxia. 23. Necessity of ventilation impressed. 24. Diaphragmatic and costal breathing — breathing of sexes compared. 25. Breathing chiefly by upper ribs — effects; corset compression — effects on breathing. 26. Benefits of deep breathing. 27. Breathing of gymnasts, singers, etc. 28, 29, 30. — Respiratory sounds — nature, cause indicative to physician. 31. Atmospheric pressure and respiration — breathing in elevated regions — rapidity. 32. "Mountain sickness" — cause, symptoms. 33. Acclimated to rarefied air — effect on different persons.

CHAP. XIV. — 1. The atmosphere; effects of impure air in general — germs of disease. 2. Composition of air; essential constituents; accidental components — increase of. 3. Oxygen — quantity, vital principle of air. 4. Nitrogen — nature, office. 5. Chief of accidental constituents — effects of increase, sources of; imperfect combustion. 6. Animals and plants in rela-

tion to oxygen and carbonic acid. 7. Watery vapor in air — variations, vapor of breath — amount. 8. Ammonia in air and breath. 9. Ozone — nature, where present. 10. Dust in air — kinds, sources, effects on organs. 11. Mouth-breathing; nose-breathing. 12. Use of respirator — dust-filter, benefits of. 13. Bacilli — nature, where present; disinfection. 14. Death from tainted air — logic.

CHAP. XV. — 1. Object of ventilation. 2. Air in cities and occupied rooms — nature of. 3. Oxygen exhaustion — breath, lights, fires; re-breathing. 4. Twofold object of ventilation. 5. Scientific ventilation — calculations involved; difficulties of adapting methods. 6. Neglect of provision in dwellings; ventilation among ancients, etc. 7. Principles and means of ventilation — currents, fires, fans, etc. 8. Artificial methods of ventilation — indispensable locally. 9. Requisites of effective ventilation — entrance, exit, distribution. 10, 11, 12. Natural ventilation — wind, unreliable; movement caused by varying temperature — nature. 13, 14, 15, 16. Methods of ventilation — inlets and outlets located — philosophy of; sub-division of current, direction; window apparatus — board inserted, sash perforated, pivot sash; opening through wall — location, fixtures, dust intercepted. 17. Air outlets — chimney-valve, partitioned shaft, currents moving. 18. Ventilation by propulsion and aspiration — apparatus. 19. Quantity of air required — proportion of carbonic acid; number cubic feet of air per person and renewal. 20. Lights and fires and air impoverishment. 21. Removal of waste matters — importance, disease result of negligence. 22, 23. Cess-pools — source of danger, pollution of air and water; proper construction, ventilation, traps, connections. 24. Basement drains dangerous, periodical cleansing of pools. 25, 26, 27, 28, 29. Sewers — construction, discharge, ventilation, traps for sewer-gas in waste pipes, flushing, house-drain ventilation and its importance, disposal of solid refuse. 30. Disinfection and destruction of *bacilli* of contagious diseases. — 31, 32. Effects of alcohol and tobacco — shrinking of corpuscles, diminished oxidation, thickening of tissue of the lungs, production of “rum consumption.” Tobacco — inhaled particles, effects of cigarette-smoking, tobacco and the voice.

NUTRITION AND DIGESTION.

CHAPTER XVI.

NUTRITION.

1. Necessity of Food. — Particles of our bodies are being constantly worn out, and are being continually carried out from the various tissues by the organs of excretion, the lungs, skin, kidneys, etc. New material must be introduced to replace the waste of tissue and maintain the normal phenomena of life. Food is material by which the waste of the body may be repaired and the bodily substance renewed.

2. In addition to its primary use in renewing the substance of the body, the food also acts as fuel in supplying material which, when duly burned (oxidized) in the body, maintains the bodily heat, and supplies energy, or the power of life and action. However, these latter offices of food are essentially included in the statement that food is matter by which the body repairs its losses, renews its substance, and maintains its life.

3. Hunger and Thirst. — Hunger and thirst imperiously remind us of the unceasing necessity of repairing loss which the body sustains through the actions of life. *Hunger*, Nature's demand for building material and heat-making

substances, may be withstood for a time which varies according to age and individual strength ; and while it is, at first, simply an agreeable sensation, it soon becomes a torture, "a succession of atrocious pains," and physical destruction soon follows.

4. *Thirst* is, on the contrary, a sensation somewhat distressing from the first, and it cannot be endured as long as hunger. It implies a privation of all liquid aliment, and exhaustion or death ensues much sooner from thirst than from hunger. It has been estimated that the length of time a man can exist without solid food and drink is about seven days. If water alone be supplied, life may be prolonged for many days, there being cases known in which men have lived twenty days or more on water alone.

5. **Classes of Food-stuffs.** — Any substance which, when taken into the body, sustains and nourishes it, or, by being burned within it, generates regular heat and energy, is a food. All vegetable and animal food-substances contain three or four of the elements, *carbon*, *hydrogen*, *oxygen*, and *nitrogen* ; and other elements are plentifully supplied by water and by inorganic, or not-living, substances, such as salts of certain alkalies, earths, and metals. In ultimate analysis, the human body also proves to be composed of the same four elements, plus water, and the same saline matters, etc., as are found in the food. Foods are of different classes, and differ in nutritive properties, according to the proportions, arrangement, or absence of any of these elements in each. And yet it should be stated that a number of conditions that remain to be noticed influence the nutritive value of food. Food-stuffs may be divided into the following-named groups :—

- (a) Proteids, or nitrogenous food.
- (b) Fats, or oils.
- (c) Amyloids, or starches.
- (d) Minerals, — water, etc.

6. ¹ **Proteids, or Nitrogenous Foods.**—Nitrogen is a gas which forms nearly four-fifths of the air; and it has been shown by chemistry that this substance also exists in another form, which may be termed solid, in every living animal and vegetable body. That is to say in regard to our bodies, if a part can feel as a nerve, think as a brain, contract as a muscle, or see as an eye, it contains nitrogen. This substance, nitrogen, is one, and perhaps the most important, of the elements of food and physical bases of life. “When we recollect that the blood, muscles, and all the vital organs contain proteids as their chief constituents, we can understand the importance of taking food rich in one or more members of this group.” Deprive an animal of food containing nitrogen, and it will ultimately starve, no matter how abundant the supply of other food-elements.

7. During the daily action of the body, nitrogen is always passing off from it, and hence must be replaced daily. We do not obtain from the air, by breathing, the nitrogen required to renew our tissues; it appears that we gain no nitrogen in that way, and that we gain it only by food. The food which contains this nitrogen, more or less abundantly,² is called *nitrogenous food, proteids, or albuminoids*.

¹ *Pro'te-id*, one of certain nitrogenous principles (albumen, gluten, fibrin, casein, etc.) forming the chief solid constituents of blood, muscles, etc., of animals, and occurring in almost every part of vegetables.

² The amount of proteid in meat is from 15 to 23 per cent; milk, 3 to 4; pease

8. The chief nitrogenous or proteid substances are *albumen*, as the white of an egg, etc.; *casein* of milk; *fibrin* of meat and vegetables; *gluten* of grains and flour; and *legumin* of pease, beans, etc. The similarity of these substances, animal and vegetable, is quite remarkable. Which, then, of all these will feed the body with the necessary nitrogen? The answer is, "They will all do it, and so perfectly that, if we have enough of any nitrogenous food (and take also proper quantities of non-nitrogenous food), the body will retain its strength through a due repair of its tissues." The old controversy as to the respective merits of animal and vegetable food has lost much of its significance. Both these kingdoms supply nitrogenous foods which man can use, and with any of them may attain the highest physical and mental development.

9. **Fats, or Oils.**—There are substances, equally entitled to be called foods, which contain no nitrogen. Fat, or oil, is a food, and a very important one; and all nations take this, in greater or less quantities, in some form. We take it in the fat of meat, or in butter, milk, and other articles of food. The Hindoo has his clarified butter, or a vegetable oil; many African tribes take it in the form of vegetable oil (olive, palm, etc.); some of the people of the far North take it as seal or fish oil. The quantity varies according to the temperature of the region, being larger in cold climates, or in winter, than in warm climates, or in summer; and it is an indispensable food. Fatty articles of diet are chiefly employed in the animal

and beans, 23 to 27; grains and flours, 8 to 11; bread, 6 to 9; potatoes and greens, 1 to 4; and the white of an egg, which is nearly pure albumen, contains 15 per cent of nitrogen.

economy to sustain the heat of the body by their combustion. While they are especially rich in the two combustible substances, carbon and hydrogen, they contain much less oxygen than the amyloid, or starch group, and therefore form the highest grade of heat-making food.

10. Liebig and other modern chemists advance the theory that non-nitrogenous foods do not nourish the tissues, but simply supply carbon for combustion and consequent evolution of heat; and this idea has been taught by physiologists until recently. While the tissues of the body are, without doubt, mainly constructed and repaired by the nitrogenous group, recent observations and experiments have shown that the fats and starches not only evolve heat, but no inconsiderable force also.¹

11. **The Amyloids, or Starches.** — The third group of food substances comprises starch, and the various forms of sugar, gums, etc. While rich in other elements, they contain no nitrogen. We obtain from this group much the largest quantity of our food; and its members, one and all, are products of vegetable life. Found largely in wheat, oat-meal, corn, rice, arrowroot, potatoes, etc., they are very important, and contribute to the bodily force and production of animal heat. The starches, entering largely into bread and all of the cereal grains, are quite certain to be taken in sufficient quantity where these are used for food. In potatoes, which are a valuable protective against scurvy, there is a large quantity of very digestible starch. It is a peculiarity of starch that it is easily converted into

¹ However, all the elements of nutrition, whether heat-forming or tissue-forming, are so sufficiently distributed throughout those portions of both the animal and vegetable kingdom which we use as food, as to cause, usually, no great or practical difficulty in nutrition, etc.

sugar by the processes of digestion, as will be explained in a succeeding chapter.

12. Water and other Mineral Foods. — *Water* constitutes about seventy per cent of the adult body. It forms the greater part of the blood, and serves there as a carrier of other substances which it holds in solution or in suspension. It forms a portion of all the tissues of the animal body, and exists as a component part of every kind of vegetable life. Our bodies constantly lose water by evaporation from the skin, exhalation from the lungs, and excretion from the kidneys, etc., and this loss must be compensated by the drinking of water and by taking foods which contain it in large quantity. Meat, equally with the muscles of our bodies, is about 75 per cent water; milk about 85; fruits and vegetables 70 to 90; and bread about 35. Only a small quantity of water is necessary as a drink under ordinary circumstances, provided that our diet and voluntary habits are physiologically correct. The vast quantity taken into the system may sometimes be accounted for through the thirst-making effects of concentrated food, excess of salt food, spices, etc., and of alcoholic drink. It is indispensable to perfect health that water to be drunk, or to be employed in cooking, should be *pure*. (See chapter upon drinks.)

13. Mineral Salts, etc. — About seventy per cent of the bone of an adult is mineral matter, the greater part being phosphate of lime; and the carbonate of lime and phosphate of magnesium are found in less quantity. The blood, and the muscles and other tissues, contain salts of potash and soda, and also iron in small quantity. These inorganic matters, essential to the growth and nutrition of the body, are found in the various articles of food, both

animal and vegetable ; and hence certain mineral elements are not usually taken separately as food. In cases of disease, as when the system appears to require more of any of them, they are taken as medicines. The "rickets" in children indicates a lack of some mineral element in the bones.

14. Common *salt* (chloride of sodium) is one of the most important mineral foods. It is not generally found in sufficient quantity in the animal and vegetable foods as supplied by nature, and is therefore added separately as a condiment. The natural craving for it attests its value ; it improves the flavor of food, sharpens the appetite, and improves digestion. In countries where salt is scarce, it is sold at fabulous prices ; and it is related that certain African tribes exchange gold for salt, ounce for ounce, and that "brothers will sell their sisters, husbands their wives, and parents their children, for salt." Deer and other animals sometimes travel hundreds of miles in search of "salt-licks." It has been found that when cattle, horses, etc., are deprived of salt, their coats become rough, their spirits dull, and that they do not thrive well ; *i.e.*, they lose health and strength.

15. **Necessity for a Mixed Diet.** — In most instances, no single article or single class of food is complete in its composition, there being usually one or more of the essential elements of a properly balanced food wanting. Thus, *meat*, while abounding in nitrogenous and fatty substances, is deficient in amyloids or starches. *Vegetables*, on the contrary, are usually rich in starch and sugar, but deficient in nitrogenous elements.¹ To illustrate : *Meat* taken alone,

¹ For this reason, foods poor in certain elements should be taken with other food rich in these constituents.

or mainly, supplies an excess of nitrogen ; and in order to obtain from meat a due amount of other elements, we should have to take several times the amount of nitrogen necessary for healthful nutrition, and, in the words of Huxley, "charge the system with imperfectly assimilated compounds, and wrongly changed products of decomposition, which produce a gouty state of the constitution." On the other hand, *bread* is deficient in both nitrogen and fat ; and hence in order to obtain the proper amount of these by bread alone, it would be necessary to eat a very large quantity of it, and, by so doing, receive more than enough of other elements, or else starve the muscles, etc., from lack of nitrogen. Again, if the saline elements are withheld, softening or deformity of the bones is the legitimate consequence. Instances of excess or of deficiency in food-elements might be multiplied.¹ Hence, the system needs and craves a *varied diet*. Confinement to a single alimentary principle, or to any one class of them alone, will generally result in loss of appetite and in disease.

16. It should be understood also, that nutriment may be of so concentrated a nature as to make its digestion difficult or impossible, and that the value of an article of food does not depend entirely upon the amount of nutritious matter it contains. In order to perform its work well, the stomach requires a certain amount of distention, and therefore a certain volume or bulk is required in the food ; hence, very nutritious, concentrated food is generally most valuable when mixed with less concentrated or more

¹ "If one should attempt to live upon potatoes only, the weight of the food that he would have to take each day in order to get the minimum quantity of proteids upon which life could be sustained would not be less than ten pounds. . . . This would lead to great distention of the digestive organs, and render one dull and stupid." — DR. V. C. VAUGHAN in '*Healthy Foods,*' etc."

bulky food. And, finally, if any essentials in food be lacking, the system soon feels it; and a person may recover from a temporary disturbance of nutrition by a simple change of diet, the necessity for which is often indicated by a longing for particular articles of food which contain the lacking ingredient.

17. Proportion of Food-elements and Quantity of Food. — Sanitarians have devoted much time and observation to the effort to determine the proper quantity and proportions of the different food-stuffs required to maintain an average person in health. The results of these observations are, briefly stated, as follows: "A healthy, full-grown American, doing a moderate amount of work, requires daily about four and one-half ounces of dry nitrogenous, three ounces of fatty, and fifteen ounces of sugary and starchy food, besides an ounce of saline matter. That is to say, in order to retain his full strength and weight, he must eat *and thoroughly digest*, every twenty-four hours, rather more than a pound of meat and eggs, about two pounds each of bread and potatoes, or their equivalent in other starchy and saccharine foods, with nearly a quarter of a pound of butter, lard, and suet."¹ Under ordinary circumstances, the penalty for taking less than this amount is loss of flesh and strength; and, on the other hand, the results of excess are derangements of the stomach, liver, and intestines, by overloading them, and, consequently, the production of dyspepsia, biliousness, diarrhœa, or constipation, with the train of evils that attend them.

18. And yet, the varying conditions under which we live should diminish or increase the amount and govern the character of our food. Exercise or labor, the influence of

¹ "Long Life and How to Reach It," by DR. J. G. RICHARDSON.

climate, etc., are among the most important modifying conditions. A person engaged in hard muscular labor may require one-fourth more, while another of sedentary employment or habits may require less than the quantity mentioned. It has been estimated that "as a rule, women need about nine-tenths the nourishment required by men, boys of sixteen about the same as women, and children of ten years half as much as adults require."

CHAPTER XVII.

VALUES OF ARTICLES OF FOOD.

1. Vegetable Foods. — The *cereal grains* most commonly used for food in the United States are wheat, rye, oats, corn, and rice. Their most important food constituents are starch, nitrogenous substances (gluten, etc.), and small amounts of fat, sugar, gum, and mineral substances. *The leguminous seeds* most used are pease and beans, both of which are richly nitrogenous.

2. Wheat, a leading article of vegetable food, is raised in preference to all other grains wherever it can be readily cultivated. It is rich in nitrogenous matter, fat, and salts, and is considered the most nutritious of the cereals.

3. Rye does not differ greatly in its composition from wheat; but the gluten of rye is inferior in quality to that of wheat. Rye is much used in Russia, Northern Germany, and Scandinavia, but not very extensively in this country. This grain is liable to become diseased; and *spurred rye* or *ergot* (a narcotic poison) has been the

cause of several epidemics of poisoning in Europe, the rye-bread eaten having been made from diseased grain. The amount of sugar contained in rye has caused it to be extensively used in the manufacture of whiskey, beer, etc.

4. *Oat-meal* is richer in fat than wheat or rye, and is a highly nutritious article of food. Formerly used almost exclusively in Scotland, it is now being largely used in this country. Its cheapness and nutritive properties should commend it everywhere.

5. *Corn-meal or Indian-meal* is used largely in our Southern States. "Prepared as the people there know so well how to prepare it," it is a very valuable food. It contains, however, but little gluten, and will not make good fermented bread unless it is mixed with wheat or rye flour. *Hominy* is a preparation of corn coarser than meal. Corn is especially rich in sugar and starch. The greater part of its nitrogenous matter is vegetable fibrin.

6. *Rice* is a grain of Asiatic origin; and although it is the chief food of the swarming millions of China and India, it is the least nutritious of the grains here mentioned. It is not rich in proteids and fats; and as its heat-producing properties are not great, it is well adapted for use in warm climates and during our warm summers. It is easily digested, and hence is valuable to the sick. It contains so little nitrogen that large quantities of it must be eaten in order to obtain that necessary element, if eaten alone, and hence it is usually prepared with milk, etc.

7. *Barley*, though largely used in Northern Europe, is not extensively employed in this country. It is less nutritious than wheat, containing only about one-third as

much gluten, but nearly an equal quantity of sugar and starch.

8. *Pease and Beans* belong to the leguminous¹ seeds. Though similar in constituents to the cereals, they contain much more nitrogenous matter than any other vegetable food. While the nitrogenous matter of the cereals is principally gluten, that of pease and beans is casein. Gluten, however, is more easily digested than casein, and hence pease and beans frequently cause disturbance in the stomach and bowels. In the green state they are more easily digested than when dried; and when dried they require long and thorough boiling. They should be soaked for several hours before they are cooked. Their nutritive value is considerable; but on account of their difficult digestion, they should not be taken in large quantities. Their deficiency in fat is made good by serving them with bacon and other fatty articles of food.

9. *Potatoes* are probably of more nutritive value than any other article of food which grows under the surface of the ground. Originally natives of South America, they were not generally cultivated in England till the middle of the eighteenth century. They are found abundantly in the wild state in Chili and Peru. While potatoes contain only about twenty-five per cent of solids, and are not rich in nitrogenous matter and fat, they will continue to be one of the most valuable of foods. The deficiency in nitrogen and fat is made up by cooking potatoes with fat, meat, and other foods. Potatoes are agreeable to the taste and are easily digested; "new" potatoes are usually not so easily digested as old, mealy ones. In order to retain the salts, potatoes should be cooked with

¹ *Le-gū' mīn*, a principle obtained from the seeds of plants; vegetable casein.

their skins on. When it is desired to boil them, the water should be hot before they are put into it. Sweet potatoes are similar in composition to the common or white potatoes.

10. The following table gives the average composition of the grains, seeds, etc., which have been mentioned:—

Articles.	Water.	Pro- teids.	Fat.	Sugar.	Gum.	Starch.	Cellu- lose.	Ash.
Wheat	13.56	12.42	1.70	1.44	2.36	64.07	2.66	1.79
Rye	15.26	11.43	1.71	0.95	4.88	61.99	2.01	1.77
Oat-meal	12.37	10.41	5.23	1.91	1.79	54.08	11.19	3.02
Corn-meal	13.12	9.85	4.62	2.46	3.38	62.57	2.49	1.51
Rice	9.55	5.87	1.84	—	2.85	73.00	5.80	1.09
Buckwheat	12.63	10.19	1.28	—	2.85	69.30	1.51	2.24
Pease	14.99	24.04	1.61	—	—	49.01	7.09	3.26
Beans	14.76	24.27	1.61	—	—	49.01	7.09	3.26
Potatoes	75.77	1.79	0.16	—	—	20.56	0.75	0.97

11. **Other Vegetables, or Garden Produce.** — The leading and most nutritious of vegetable food-articles have been briefly noticed; but there are other succulent vegetables, which, while not highly nutritive, are used principally because they furnish variety, supply certain acid salts, prevent scurvy, and render other foods more digestible. The following is a brief statement of the values of a few of them:—

12. *Beets* are rich in sugar, containing about 10 per cent of it, and hence are quite nutritious. They are the chief rival of the sugar-cane.

13. *Turnips, carrots, and parsnips* consist mainly of

water (82 to 90 per cent). They are from 2 to 6 per cent sugar, from 5 to 10 per cent starch, and contain very small quantities of nitrogenous matter, fat, and salts.

14. *Cabbage* and the so-called "greens" generally contain less than 5 per cent of nutritious matter; but in spring their juices and salts are highly beneficial.

15. *Tomatoes* are more than 92 per cent water, less than 2 per cent starch, and about $2\frac{1}{2}$ per cent sugar; whether raw or cooked, they are an agreeable and beneficial food.

16. *Asparagus* is one of the most wholesome and nutritious of the garden products.

17. *Rhubarb* is strongly, though pleasantly, acid. As it is one of the earliest of spring plants, it is especially valuable.

18. *Cauliflower* is not as nutritive as cabbage, nor so palatable without seasonings.

19. *Pumpkins and squash* each contains only about 1 per cent of nitrogenous matter, 1 per cent of fat, 1 to 5 per cent of starch, 1 per cent of sugar, and water constitutes the remainder, or greater bulk. Cooked with other more nutritious foods, such as butter, milk, etc., they make very palatable dishes.

20. **Fruits.** — Estimated by their chemical constituents, the value of fruits as food is small; but when properly ripened and well preserved, they are of great benefit to the system. They sharpen the appetite, make other food more enjoyable, and aid greatly in maintaining a healthy condition of the stomach and other vital organs. Fruits are especially valuable, and hence much used, in warm countries and during our summers, as they produce but little animal heat. The juice of fruits, consisting of water, sugar (from 1 to 18 per cent), and acids, is the most

agreeable and valuable part; the skins and cellular portions are not easily digested, and those fruits which contain most juice and least cell-fibre are preferable. Boards of Health have of late years been doing much in the inspection of food supplies, but have found it almost impossible to prevent the sale of fruit unfit to be eaten. Fruit being a highly perishable commodity, vendors buy it before it ripens naturally, and permit it to ripen, or, rather, decompose on their stands. The result is that fruit kept and exposed in this manner is at no time really fit to be eaten, as it passes from greenness to rottenness without being *really* ripe. Such fruits are extremely dangerous, and should not be eaten.

21. Canned Fruits sometimes become partially decomposed, and cases of serious or fatal poisoning have followed the eating of such fruit. Tin cans are sometimes used twice or oftener for the preservation of fruit, vegetables, etc., and the contents of such cans are liable to absorb small quantities of the salts of tin and lead, which are poisonous.¹

22. Confectionery.—Candy is about as valuable as an article of food as the sugar, starch, and gum which compose it; and, when pure, it is not injurious unless when taken in excess. Sometimes, however, candy is adulterated with harmful substances and poisonous coloring-matter. Instead of containing simply sugar, flour, gum, and such innocent ingredients, *terra alba* ("white earth," or gypsum, which is heavy and cheap) is mixed with it; and

¹ Dr. Vaughan recommends the following precautions relative to tin cans of fruit: "In buying fruit-cans, it should be observed that the ends of the cans are concave. If convex, there has probably been some decomposition of the contents with the evolution of gas." Again: If the cans are old and battered, they should be suspected of having been used more than once for the purpose of preserving fruit.

in any considerable quantity terra alba is harmful on account of being indigestible. Gritty, chalky candy should be rejected. Green, bright-yellow, and orange candies may be poisonous, because the coloring agent in these is most frequently chromate of lead. Ultra marine is also harmful when used in large quantities as a pigment. White candy is probably the most wholesome.

CHAPTER XVIII.

VALUE OF FOODS (*concluded*).

1. Animal Foods.—Mankind obtain a large proportion of their food from the animal kingdom. The quadrupeds, fowl, and fishes of the waters supply a great variety; and there are but few parts of an animal that have not been more or less employed as human food, in the quest for variety. The alimentary principles derived from animal food are protein, gelatine, oleaginous, and the saccharine matter of milk; in other words, *fibrin*, *albumen*, *casein*, *gelatin*, and *sugar*. They are yielded by the muscles, fat, cartilages, ligaments, cellular and nervous tissue, milk, and eggs of the animal kingdom.

2. The lower animals eat vegetable food, and appropriate or build up its elements into their tissues; and these tissues, similar in chemical elements to the flesh of man, are made use of as food by him.

3. Of the food derived from animals, meat is one of the most important, and consists of water, mineral salts, albu-

men, fat, etc. Herbivorous animals, those which feed upon vegetables exclusively, are usually preferred as food to those which prey upon other animals. Omnivorous animals, which eat indiscriminately vegetables, or other animals, are by some believed to be inferior as food to the purely herbivorous ; and the carnivorous, which subsist upon other animals exclusively, are still more inferior. In the most civilized countries, the domesticated animals afford the principal flesh-meat.

4. Circumstances affecting the Value of Animal Food. — The quality of food derived from animals may be greatly varied by circumstances. The age of the animal and the manner in which it has been prepared for market have a marked influence upon the quality and composition of the flesh. Very young or very old animals are less valuable for food than those nearly full-grown or middle-aged. Again, animals which have been excessively and quickly fattened, or stall-fed, and those which have been “slop-fed” with liquid preparations, the refuse matters of the kitchen or of distilleries, are more or less deteriorated in food value.

5. *The quality of meat is also affected by the manner in which the animal is slaughtered.* All flesh contains blood, much of which is venous and impure from the waste and effete matter which is about to be expelled from it ; hence the slaughtering is, or should be, so conducted as to remove as much of the blood as possible. The Jewish custom of soaking meat half an hour in water, and then letting it lie an hour in salt before cooking, was for the purpose of further cleansing it of blood ; and the Mosaic regulations relative to the use of flesh as food were philosophical.

6. In all animal structures, the process of decomposition begins soon after life is extinct; and although the evidences of such change may not be offensively evident to the senses of taste or smell for some time, the sooner meat is eaten after the *rigor mortis* (stiffness of death) has left it, the better, especially in warm weather and when meat is not kept frozen. Some epicures have meat kept till it becomes tender from age, but such tenderness is a condition of the first stages of putrefaction; and although the article may be more easily masticated by the teeth, and very quickly *dissolved* in the stomach, it cannot be properly *digested*, nor can it be converted into pure blood and sound tissue. The flesh of a healthy animal may become poisonous from partial decomposition; and hence to make tough meat tender, it is much better to break up its fibres by thorough pounding before cooking, thus making some allowance for the masticatory ability of imperfect teeth, or of artificial ones.

7. *The value of meat, and also of other foods, is influenced by the manner of cooking.* Proper cooking not only renders food more agreeable to sight, smell, and taste, but by so doing stimulates the flow of the digestive juices and renders the food itself more digestible.

8. **Meats which should not be Eaten.** — The following list of flesh-meats which should not be eaten is given by Gerlach, director of the Royal Veterinary School at Berlin: —

(1) The flesh of animals which have died of internal diseases, or which have been killed while suffering from such diseases, and of healthy animals which have been killed by over-driving.

(2) The flesh of animals having contagious diseases which may be transmitted to man.

(3) The flesh of animals which have been poisoned.

(4) The flesh of animals having infectious diseases, such as blood-poisoning from wounds, etc.

(5) Flesh which contains parasites that may be transmitted to man, such as pork containing *trichinæ*, a small worm.

(6) All decomposing or putrid flesh.

9. Special Properties of Meats in Common Use. — *Beef* ranks first in value of all the meats used by civilized people. Scientific investigation, as well as common experience in its use, proves that beef is most nutritious, and that a smaller quantity of it than of any other flesh-food will appease hunger. Meat from different animals of the same class varies in composition, flavor, and digestibility, as has been already intimated; and this is also true of different portions of the same animal. In beef, and in the order in which they are mentioned, porter-house, sirloin, and round steak are considered most valuable; and from these the scale of values descends to neck and flank pieces, which are considered to be least valuable. In color, good beef is reddish-brown. Beef of a pale-pink color should be suspected as having been taken from a diseased animal; and that of a dark-purple color, as being the flesh of an animal which has not been properly slaughtered (or not slaughtered at all), and which died without sufficient bleeding. Wholesome beef has little if any odor, at least is not disagreeable to the sense of smell. Meat of any kind which is wet and inelastic to the touch is not in good condition.

10. Veal, the flesh of calves, is considerably less nutritious, and not as easily digested as beef. Veal from very young animals is unwholesome; in some localities, the

slaughtering and offering for sale as food of calves under one month old are prohibited by law. Veal, especially when too young, is apt to cause cramps and diarrhœa; and some stomachs cannot digest it at all.

11. *Mutton*, though more easily digested than beef, is less nutritious. From its easier digestion, mutton is better adapted than beef to the powers of a dyspeptic stomach; and it is well known that mutton broth is especially valuable as food in cases of dysentery. Lamb is less nutritious than mutton, and, like veal, it is not suitable for weak stomachs.

12. *Pork*, for various reasons, is one of the most important of meats. Hogs can be fattened more easily and cheaply than oxen or sheep, and they usually store up in their structure in the form of fat several times as much of the food which they eat as oxen do. Pork is a heat-producing food, and is well adapted for use in cold weather. It contains less nitrogenous substance and is less nutritious than beef. Hogs are too frequently fed unwholesome and unclean food, and consequently their flesh deteriorates proportionately in wholesomeness. Of all the meats, pork is the one most liable to be diseased, and is quite frequently infested by a minute worm known as the *trichina spiralis*. It has been found that a cubic inch of pork may contain nearly a hundred thousand trichinæ. The young trichinæ are hatched out in the intestines of those who are so unfortunate as to eat diseased pork, and burrow their way out into the muscles of all parts of the body, setting up inflammation which often results in death. Trichinæ are not easily killed, and neither smoking nor salting of pork accomplishes their destruction. As their presence in pork cannot be discovered without the aid of

the microscope, it is never safe to eat the meat unless it has been thoroughly cooked. The smallest fragment from the interior of a ham which escapes being heated to nearly the boiling-point of water (212°) may carry a number of living trichinæ into the stomach of one who eats it.¹

13. Salt extracts juices from meat ; and as these remain in the brine, salt meats are usually less nutritious than fresh meats. Dried meats are, as a rule, less easily digested than the same meats when fresh ; but *bacon* and *ham* are exceptions to the rule, as, when properly cured, they are digested more easily than fresh pork.

14. *Fowl, or poultry*, is usually more easily digested than the meats thus far mentioned, but is regarded as less nutritious. Poultry and game are less juicy than the other meats, and, as a rule, contain less fat. The white meat of fowls is more easily digested than the dark meat, but it is not as rich in nitrogenous matter and in flavor as the latter. Chicken broth is more delicate in flavor and more nutritious than that made from beef or mutton, and is therefore a valuable food for the convalescent. The flesh of carnivorous birds is not in itself poisonous, but is generally strong in odor and not agreeable in taste.

15. *Fish* is poorer in nitrogenous elements, but richer in certain important salts, than the meat of warm-blooded animals. Fish which have red or pink flesh are richer in nitrogen than those whose flesh is white. Fish undergoes rapid decomposition, and when decomposition has set in is highly unwholesome. It should never be eaten

¹ "The trichina disease comes on generally with violent vomiting and diarrhœa, followed by high fever, with severe pains in the limbs, back, and head. For some time it can scarcely be distinguished from acute poisoning, or sometimes from typhoid fever ; but about the seventh or eighth day a peculiar swelling of the eyelids and root of the nose indicates the true nature of the disease."

except when undoubtedly fresh. Stale fish has shrunken eyes, bloodless gills, and presents a withered appearance in general ; but as vendors sometimes resort to expedients to improve the appearance of stale fish, the most reliable test of freshness is the odor. Of the crustaceans, *lobsters* and *crabs* closely resemble the other fish in constituent elements, but are more muscular and less easily masticated and digested ; besides, their flesh is peculiarly inclined to rapid decomposition, and when eaten in this condition it frequently causes sickness which may result fatally. *Clams*, whether raw or cooked, are difficult to masticate and very indigestible. *Oysters*, while not very nutritious, are delicate in flavor and easily digested, more particularly so when raw. There exists a popular belief that fish is a food which is especially adapted to the development of brain and nervous structures, but its supposed advantages in this particular lack scientific confirmation.

16. Milk, etc. — Milk contains representatives of all the classes of food, and therefore has all the elements required for prolonged nutrition. It should be the principal food of young children, and for adults it forms a palatable and easily digested article of diet. Some invalids cannot enjoy it, and some dyspeptics cannot tolerate it ; but exceptional cases from morbid conditions are not rules for healthy persons. Milk is composed about as follows : water, 87.5 ; casein and albumen (nitrogenous constituents), 3.5 ; fat, 3.5 ; milk sugar, 4.8 ; ash (salts, etc.), 0.7 per cent. This, however, is only an average composition, as no two cows yield milk which is precisely alike in chemical elements ; and milk from the same cow varies with the manner of feeding, quality of the food, etc. Cows fed in close, filthy stables, upon warm slops and other

refuse matters of distilleries, become diseased and often consumptive; and the "swill milk" from such animals is, consequently, unwholesome and disease-producing. "Barn-yard milk" is the name sometimes applied to milk yielded by unclean animals, or by those kept in filthy, unventilated stables. Such milk has absorbed odors which are plainly perceptible, and which, while they may not render it absolutely poisonous, make it repulsive and to a certain degree unwholesome.

17. *Adulteration of milk* is quite common, and is accomplished in several ways. The addition of water is the fraud most commonly resorted to, the effect of which is to lessen the nutritious properties of the milk. This adulteration can be detected usually by means of the lactometer (an instrument designed to test the specific gravity of milk); but even this test cannot be relied on in all instances, because artful and dishonest persons sometimes increase the specific gravity of watered milk to the required standard by dissolving salt or sugar in it. "To furnish a child with watered milk is often to slowly starve it to death, and the person guilty of such an act should be treated as a criminal." — (*Dr. V. C. Vaughan*). In some States such adulteration is prohibited by law, and regularly authorized inspectors are appointed whose duty it is to examine milk and prosecute those who adulterate it. Watery, innutritious milk may be produced by feeding cows sloppy food, reference to which has already been made. Akin to the dilution of milk by adding water, is the removal of more or less of the cream by skimming, thus robbing it of nutritious properties. The greater or less amount of cream which forms upon milk contained in a tall, narrow vessel is a simple but quite effective test of richness.

18. Care of Milk. — Disease Germs. — The care of milk is extremely important, as there are so many ways in which it may become contaminated, and hence dangerous to health and life.¹ The following precautions should be observed in the care of milk : (1) For the reason that milk rapidly absorbs gases, and because dust which falls into it may contain disease germs, it should never be allowed to remain in an uncovered vessel in an occupied room. (2) It should not be kept for any length of time in metallic vessels (copper, brass, or zinc), or in earthen vessels glazed with lead. If the milk becomes even slightly sour, its acid may dissolve sufficient of the metal to render the milk poisonous. (3) All vessels which have contained milk should be scalded with boiling water before they are used again. The most scrupulous cleanliness is necessary in order to keep milk wholesome.

19. *The different ways in which milk may become so infected as to transmit disease* are presented briefly by Dr. Vacher, as follows : (1) The milk may be derived from a tuberculous cow. (2) It may be derived from a cow having a specific epizoötic disease. (3) It may be drawn from an inflamed udder. (4) It may have undergone chemical or fermentative change. (5) It may have become infected with the contagion of an animal disease. (6) It may have become infected with the con-

¹ Cases of poisoning by milk occurred at one of the hotels at Long Branch in the summer of 1886. The investigations of the experts proved that the cause of the sickness was poisonous milk, and that the toxic element in it was *tyrotoxinon*. The report of the experts says : "The production of this substance was no doubt due to the improper management of the milk, that is, too long a time was allowed to elapse between the milking and the cooling of the milk ; the latter not being attended to till the milk was delivered to the hotel ; whereas, if the milk had been cooled immediately after it was drawn from the cow, fermentation would not have ensued, and the resulting material, *tyrotoxinon*, would not have been produced."

tagion of a human disease, either by germs falling into it, or by means of polluted water with which the milk was adulterated, or with which the vessels containing it were washed. Wide-spread epidemics of scarlet fever and typhoid fever have been unmistakably traced to the milk supply. "In one instance, cases of typhoid fever broke out among the customers of a certain milkman; and when an investigation was held, this person admitted that his milk-cans had been '*washed out*' with water from a certain well which was proved to be infected by sewage from a neighboring cess-pit containing typhoid fever excrement." The germs of diphtheria may, in like manner, be distributed in milk.

20. *Two preventives of mischief are recommended to the consumer:* (1) To examine the milk delivered to him, and to reject it if it appears to be watered, or if it is streaky, ropy, blood-stained, or smells disagreeable from any cause. (2) To thoroughly boil the milk received, though this alters its nature somewhat. To these precautions may be added that of keeping the milk in covered vessels in closets where the air is clean and cool.

21. **Butter and Cheese.**—These foods furnish the nutritious elements of milk in concentrated form. Of the fats used as food, butter is the most agreeable to the taste and most easily digested, and its food value is great. Good butter is free from rancid taste and odor. All butter contains casein which is derived from the milk skimmed off with the cream; but as rancidity is chiefly occasioned by decomposition of the casein, the less it contains, the less liable it is to become rancid, or "strong." Butter is seldom adulterated with injurious substances, except that purified animal fats, butterine and oleomargarine, are

often mixed with the poorer grades of butter. These adulterations, though repulsive, are not, as a rule, very detrimental to health. Butter, like milk, readily absorbs impurities; and the restaurant system of exposing butter to an atmosphere charged with foul matter, possibly with disease germs, is highly reprehensible.

22. *Cheese* is very rich in nitrogenous matter and fats; of these it contains an average of twice as much nitrogen and three times as much fat as an equal weight of meat. As it is a highly concentrated food, it should be taken only in small quantity at a time. When fresh, it is regarded as good food; but it is very liable to decomposition, and when this sets in, cheese becomes irritating and indigestible. Old, strong cheese, though itself very indigestible, is known to be an aid in the digestion of other substances, and is taken, therefore, as a condiment; but the quantity eaten should be very small. In taking cheese it is well to recollect the old doggerel:—

“Cheese is a *mighty* elf,
Digesting all things but itself.”

23. **Eggs.**—These are a highly nutritious article of diet, and are easily digested when properly cooked. The white of the egg consists of water and albumen, with minute quantities of mineral salts and fat; the yolk is about one-third fat; in other words, the fat of an egg is confined almost entirely to the yolk. Eggs contain neither starch nor sugar, and should therefore be eaten with articles which contain these substances. Eggs are most easily digested when taken uncooked, or when boiled sufficiently to coagulate the white without hardening the yolk. Hard-boiled or hard-fried eggs are digested

with difficulty. In the preservation of eggs, the object is to prevent the passage through the shell of germs from the air which cause decomposition; this may be accomplished quite effectively by dipping eggs in mucilage and then packing them in salt; or by simply packing them in salt alone, or in salt and lime, in these ways excluding the air. When eggs are put into a strong brine made of an ounce of table salt and ten ounces of water, the sound ones will sink, while the stale ones will float.

24. Cooking. — An article upon food would be imperfect without a reference to the best modes of cooking, as cookery and digestibility are closely related. Cooking is designed (1) to soften the food and thus render easier its mastication and solution by the digestive juices; (2) to develop its flavor and make it more agreeable in taste and odor;¹ and (3), particularly with meats, to destroy parasites and disease germs that may infest it. Careless or unskillful cooking very frequently presents us with tough, dry, tasteless dishes which are as innutritious and indigestible as they are unpalatable. Good cookery is the practical result of centuries of experience in that direction, the final flower of ages of evolution.

25. Cooking of Meat. — A chief object to be attained in cooking meat is the retention of its internal juices, and hence its nutritious elements. In all the modes of cooking meat, a high degree of heat should therefore be applied at first in order to quickly coagulate the albumen upon

¹ Some one aptly remarks, "The quantity of nourishment depends greatly upon the aromatic flavor contained in food; and whatever is insipid to the taste is of little service to the stomach. Now, the difference between good cookery and bad cookery lies principally in the development of the flavor of our food; articles properly cooked yield the whole of it; by good cookery we make the most of everything — by bad cookery, the least."

the surface, and thus retain the juices. *Broiling, roasting, or baking* of meats retains the juices and flavor better than when cooked by boiling. In these modes of cooking, the fire should be brisk at the beginning ; but the meat should not be exposed to this high heat during the entire time of cooking, else the fibre will be made hard and indigestible. *Broiled meat* is found by most persons to be most easily digested. *When meat is to be boiled*, the pieces should be large and should be put into water already boiling; but after about ten minutes the heat should be lowered to a degree at which there shall be little, if any, perceptible boiling, and this temperature should be retained till the fibre is made tender. *If soup is to be made*, the meat should be put into cold water, and the temperature slowly and gradually raised; the object in boiling being to retain the nutritious fluids, while in soup-making the design is to extract them. Albumen is instantly hardened by boiling water, while it readily dissolves in warm water. *Frying* is the poorest method of cooking meat, because it drives out the natural juices and does not compensate for this by the cooking in lard or other fat. Fried meats are usually much less easily digested than meats prepared in the other modes mentioned. In frying meat, the fat should be made very hot before the meat is put into the pan, and should be cooked rapidly and removed from the utensil immediately on becoming tender. The most common errors in cooking meat are using continuously too high a temperature and over-doing the cooking.

26. Cooking of Vegetables. — Most vegetables are usually cooked by boiling. The chief care to be taken is that the boiling process be carried far enough to soften the sub-

stance without breaking down its structure so completely as to cause it to dissolve in the water and be lost. When the boiling has softened the vegetable, it should be removed from the water before it cools, because while boiling the pores of the vegetable are filled with steam; but when cooling begins, the steam condenses and the surrounding water passes in to fill the partial vacuum, thus causing the vegetable, particularly if it be a potato, to become sodden and indigestible. Potatoes, in order to retain their natural salts, should be boiled with the skins on, and should not be put into the water until it is hot. In baking potatoes, the oven should be moderately hot. Vegetables which are deficient in oils are cooked or served with butter, lard, bacon, or other fats.

27. The Mixing of Bread. — Fermentation is a process involving a series of chemical changes by which the organic elements of vegetable substances are reduced to their ultimate or chemical elements; that is, as applied to grains, fermentation is the decomposition of the sugar, and the recombination of its elements so as to produce *alcohol* and *carbonic acid*. The alcohol produced in bread-making is mostly driven off by the heat of the oven, and the carbonic acid gas, being retained by the tenacious gluten, raises or puffs up the dough. If the dough is not thoroughly kneaded, good bread cannot be made. If the yeast is not equally mixed with every particle of the flour, the fermentation will be unequal, and some portions of the bread will be heavy or compact. While the dough must be allowed to rise sufficiently, yet, if the fermentation is allowed to proceed too far, the sugar and starch will, to some extent, be destroyed, and *acetous acid* (vinegar) will be formed, rendering the bread sour and indigestible.

When the dough has been properly kneaded, it should be covered with a napkin or light woollen blanket, and kept at about 60° Fah. until sufficiently light. "The process of fermentation is arrested at a temperature below 30°, proceeds slowly at 50°, moderately at 60°, rapidly at 70°, and very rapidly at 80°." Unfermented bread is that which is rendered light by means of acids and alkalies, or by forcing carbonic acid gas into the dough, in the latter instance making what is known as "aerated bread."

28. Baking of Bread.—All bread, whether raised or unleavened, to be easily digested, must be light, dry, friable, and so porous as to readily absorb water. Bread is also comparatively indigestible if underbaked or overbaked. It is a common error that bread can hardly be overdone in baking. Its dietetic value begins to deteriorate the moment baking proceeds too far; and as much care should be taken to remove it from the oven as soon as it is baked sufficiently as to have it remain till well done. When the crusts of a newly baked loaf are hard and thick, it is customary to wrap the loaf in wet cloths to soften it; but this practice is objectionable for the reason that it prevents the free evaporation of such alcohol as may still remain in it, thus rendering the bread more difficult of digestion. The most important food constituents of bread are the same as those of the grains from which it is made, *i.e.*, proteids, starches, and vegetable salts; and as the amount of nitrogenous matter and fats is too small for a perfect food, it is usually taken with meat, which is nitrogenous, and with butter to supply the fats; thus with these additions, bread becomes a perfect food.

29. Condiments.—In our cookery, very few simple and uncompounded flavors are left to us; everything is so

mixed that only by special experiment can one discover what are the effects of special flavors upon the palate. This makes it quite difficult for us to realize the distinctness of the elements which go to make up the tastes as we commonly experience them. Then, too, a great many food articles have but little flavor of their own, and only a feeling of hardness or softness, or glutinousness in the mouth, mainly noticeable in chewing them. Thus, plain boiled rice is almost wholly insipid, and salt is usually boiled with it; and in practice, we generally eat it with sugar, fruit, milk, or with some strongly flavored condiment. Again, plain boiled tapioca, sago, etc., are as nearly tasteless as anything can be; but milk, in which they are oftenest cooked, gives them a relish; and sugar, eggs, cinnamon, or nutmeg are usually added by way of flavoring. Gelatine by itself is merely very "swallowable;" and we mix sugar, lemon juice, and other flavorings with it in order to make it into good, tasty jelly. Condiments, therefore, are substances whose employment in cooking is for the purpose of seasoning foods. One member of this class (common salt) is necessary to healthy existence. Salt, spices, essences, vinegar, pickles, catsups, sauces, etc., are, in general, just our civilized expedients for adding the pleasure of pungency and acidity to naturally insipid foods, by stimulating the nerves of taste, just as sugar is our tribute to the purely gustatory sense; and as oil, butter, bacon, lard, etc., used in frying, are to the sense of relish which forms a last element in our compound taste. However, while much benefit may arise from the use of condiments in small quantities, large or excessive use of them sometimes proves very injurious to health.

30. Condiments are very frequently adulterated with cheaper or more harmful substances. Thus, vinegar is sometimes adulterated with sulphuric acid; table mustards, with tumeric; and pepper and other spices are sometimes mixed with flour, starch, and ground peanutshells. In order to obtain pure spices they should be purchased unground.

CHAPTER XIX.

DRINKS. — WATER AND HEALTH.

1. **Physiological Offices of Water.** — Water may be regarded as second among the primary necessities of animal life. It has been estimated that man can live without air from two to ten minutes; without water, from three to five days; and without food, from ten to fifteen days. Water is the instrument of change; and nutritive substances cannot enter the system, nor the waste of the tissues leave it, unless held in solution by water. By its solvent power it performs these necessary offices. As water is one of the substances absolutely necessary for life, its purity is not less a requisite for health. All persons, however, do not know that transparent, sparkling water is not always wholesome; and many believe that *soft* water is necessarily pure. Perfectly transparent waters may contain poisonous mineral impurities; and while pure water may be soft, soft water is not always pure. Absolutely pure water can hardly be found, but that which is most nearly pure should be sought; and sources of pollution should be watched

with great care, and all such as are preventable should be removed or avoided.

2. The chief impurities of water consist of *mineral matter* either in solution or in suspension, or both ; and of *organic matter*—vegetable and animal substances which find their way into it, and, by their decomposition, render the water unwholesome. The foreign mineral ingredients found in water in its natural state, modify its character according to their quantity and their peculiar properties, and give rise to the varieties known as *hard water*, *soft water*, *sea water*, and *mineral water*.

3. **Rain-water.**—The ultimate source of all *fresh* water is the ocean, whence, by a natural process of distillation, vapors rise into the upper regions of the atmosphere and are there condensed into rain-water, which is the purest that nature supplies. However, in descending, rain-water becomes impregnated with impurities that may be floating in the air. These impurities in the air, above and about large towns and cities, consist of gases, soot, and various other organic and inorganic atoms.

4. Again, rain-water becomes mixed with corrupting vegetable, animal, and mineral substances that are diffused more or less abundantly over every exposed surface in the neighborhood of living beings ; and hence, water collected from roofs usually contains such impurities, and has a tendency to rapid putrefaction. Especially is this the case if the roof is of wood and old, and if there are projecting branches of trees which deposit leaves and other *débris* upon the roof and in the gutters ; also when birds—pigeons, sparrows, etc.—frequent the roof. Impurities from pipes through which it flows (such as *lead*), or from foul cisterns, or other reservoirs in which it is stored,

frequently render rain-water less suitable for drinking and cooking than good well-water. In all instances, the cistern or other receptacle should be kept scrupulously clean. A cistern should be so built as to prevent the possibility of water from the surrounding soil (which may be filth-soaked) finding its way in through the walls. Being free from saline matter and certain other mineral ingredients (lime, etc.), rain-water is excellent for washing, but is rather insipid in taste. When shed from clean slate or galvanized-iron roofs, and stored in perfectly clean and tight receptacles, rain-water is, practically, the best water for general use.

5. River, or Surface Water. — The water of running streams is, in part, that which has run into them directly from the surface of the adjacent slopes, and in part that of the flow from springs, shallow or deep. As contact and considerable friction with the ground take place, saline matter and also vegetable and animal matters are liable to be taken up and to become dissolved in the water of running streams. The extent to which the water becomes impregnated with these substances depends upon the nature of the strata through which it passes, and upon the condition of the surface of the ground upon which the rain falls, and over which it flows into the stream. In thickly settled regions, the amount of refuse matter upon the surface of the ground is usually considerable, and the water collected from such sheds is unfit for drinking and cooking purposes. Besides, if the refuse of factories, drainage and sewage of towns and cities situated upon its banks flow into a stream, its water is rendered very impure and dangerous to health. In thickly settled countries there are but few rivers left from whose lower course a supply of

water for drinking and cooking should be taken.¹ That the water of running streams undergoes purification to a certain degree is undeniable ; but notwithstanding, specific poisons have been carried long distances in rivers, and have still manifested their evil effects. Hence, the great objection to water from rivers is their general pollution. When rivers are not thus polluted, this variety of water is one of the least objectionable.

6. *Water from ponds, marshes, and small streams* is apt to be impure, not having even the somewhat uncertain benefit of filtration through the earth to strain out organic impurities and the germs of disease that it may contain. Many attacks of ague, typhoid fever, dysentery, and cholera have been traced to the drinking of impure surface-water. The terrible epidemic of typhoid fever that recently resulted in the death of scores of people in a Pennsylvania town gave a fearful example of the harm that may, at any time, follow careless or ignorant pollution of streams from which water for domestic use is obtained. In this instance, the slops from the sick-room of a person having typhoid fever were thrown upon the ice-covered banks of a stream, and thence ran into it when the ice melted, poisoned the water, and carried disease or death to all who drank it.

7. **Spring Water. — Well Water.** — Subterranean waters used for drinking and cooking purposes are obtained from

¹ As an instance, the largest cities of New Jersey, Jersey City and Newark, obtain their water-supply from the lower course of the Passaic River. Only a few miles above, this stream receives the sewage of the large city of Paterson, and of the smaller city of Passaic, together with the refuse of numerous factories, dye-houses, etc. Analyses of the water-supply of Jersey City and Newark have proved it to be much polluted and unfit for drinking and cooking, and hence these two cities propose to abandon its use for domestic purposes. Above Paterson the waters of the Passaic are exceptionally pure.

springs and wells. *Spring-water* is generally clear, sparkling, and of a uniform temperature (50°) at all seasons of the year, and hence has properties that commend it to the eye and to the palate in an eminent degree. However, the purity of either spring or well water depends, primarily, upon the geological formations in which their sources are situated. In order that such water shall be pure, its source must be beneath rock, or thick beds of clay, which prevent direct contamination from the surface of the ground. Springs in gravel formations may be as impure as shallow wells, and for similar reasons.

8. *Well-water* is obtained from wells, shallow or deep. The water of shallow wells is really surface-water, often of the most impure kind. Just as a ditch collects water from a wet field, a shallow well drains water from the surface of the ground adjacent to it; and if the ground is filth-sodden from impurities that have accumulated upon and within it, these foul matters dissolve in the water and are carried into the well. It is a great error to believe that when water percolates through a few feet of earth every harmful substance is detained somewhere in the soil, and does not enter the spring or well. In passing through filth-soaked earth, the impurity of water is increased, and not diminished. In country districts the water of new wells is commonly pure, and may remain so for a long time if cess-pools, out-closets, and stables are not near them, and if kitchen slops, wash-water, etc., are not cast upon the ground in their vicinity.

9. In cities and towns where there are always many sources of pollution, — absence of proper drainage, leaky sewers and drains, numerous cess-pools, etc., — the ground becomes saturated with filth, and much foul and harmful

matter is carried into wells. A well, a cess-pool, and an out-closet are often found in close proximity in a small yard; and it has been well remarked by an eminent sanitarian, that, "If the well be a shallow one, such an arrangement is probably the worst, in a sanitary sense, that could possibly be devised."¹

10. *Deep wells*, the water of which is naturally purer than that of shallow ones, should have their walls so constructed as to prevent the entrance of water from the surface, else the water of these may become as objectionable as that of shallow wells. There is a lesson that should be learned by all, — that there are disease and death in cess-pools, filth-sodden soil, and bad drainage as related to the water used for drinking and cooking; and, while in the case of a public water-supply it is the duty of the proper authorities to use all possible means to prevent its pollution, it is equally the duty of the consumer and of those who have the care of private wells to take due care that water is not contaminated on their premises.

11. *Hardness of Water*. — Spring and well waters are often *hard*, and by this term is meant that they fail to make a lather unless a very large quantity of soap is used with them. In washing, hard water occasions chapping of the skin, great waste of soap, much extra labor, and a corresponding increase in the wear of fabrics during their washing. The hardness of subterranean waters is commonly due to the presence in them of the salts of lime and of magnesia. These salts decompose the soap and combine with the oily acid to form an insoluble compound which

¹ "Practically it is beyond all question that, in multitudes of instances, the cess-pits *feed the wells*; and it is equally certain that such wells *feed the grave-yards* of villages and districts where this culpable neglect of hygienic precautions is allowed to occur." — DR. J. G. RICHARDSON, in "*Long Life and How to Reach It*."

has no detergent properties. Hard water forms incrustations in boilers and in lead pipes. In cooking, soft water is preferable to hard water.

12. It has been a question whether hard water is, or is not, injurious to the human system. There is evidence that goes to prove that the presence of carbonate of lime in large quantities is injurious. Certain hard waters irritate the stomach and other organs of persons who are not accustomed to their use, and produce in such persons diarrhœas. In some instances the use of hard water ("lime-stone water") appears to have produced goitre (an enlargement of the thyroid gland of the neck), but this has not been positively demonstrated. Unless the hardness of water is very great, it may not unfit the water for drinking purposes; but most physiologists agree in the opinion that pure, *soft* water is best, both for man and the lower animals.

13. **Action of Water upon Lead.**—Injurious effects have frequently arisen from the contamination of water with lead derived from leaden pipes and cisterns. Some kinds of water dissolve lead quite rapidly by chemical action. Rain-water, and soft river and lake waters in general, possess the power of forming compounds with lead, which, if dissolved, render the water highly poisonous. All waters act upon it to some extent, but it is only when lead is dissolved that the water having it in solution becomes dangerous. Waters that contain vegetable acids (as from decaying leaves, etc.) act rapidly on lead; while certain hard waters, containing sulphates and phosphates, have a protecting influence by means of a coating which they deposit upon its surface, and which is believed to protect lead from further chemical action. But this coat-

ing is not always to be relied on; and water that has remained for several hours in lead pipes, especially new ones, can never be used with assured safety. In all instances it is safest to allow water to run for some time from leaden pipes before any is drunk or used in cooking.

14. Means of Purifying Water. — *Filtration* is one of the most practicable and effective methods of removing impurities suspended in water, but not those substances held in solution. Though the cleansing power of sand is not, strictly speaking, due to chemical action, yet there is no doubt that the attraction of adhesion is at work when water passes through it, and thus solid matters are intercepted by it. The effect of charcoal is supposed to be chiefly chemical.

15. A very simple and inexpensive filter recommended by Dr. Parkes, is prepared as follows: "Procure a common, earthen-ware flower-pot, and close the hole in the bottom with a piece of sponge, clean flannel (either of which requires changing from time to time), or a piece of zinc wire-gauze; then put into the pot about three inches of gravel, and upon that the same depth of white sand, washed very clean. Next place in four inches of powdered animal charcoal, and cover it with a thin layer of coarse gravel, or with a piece of slate, to keep it in place." It is perhaps better to place a piece of thick flannel over the top of the pot, large enough to tie round the rim on the outside, and to form a hollow inside, into which the water is to be poured. The flannel removes the grosser impurities floating in the water, which will flow out through the sponge or wire-gauze at the bottom in a greatly purified state. The charcoal will, from time to time, become clogged, and must then be renewed or cleansed by heat-

ing in a pan over a fire. The sand and gravel should also be cleaned, or renewed occasionally. The principle of filtration being understood, it is quite practicable under almost all circumstances, to contrive some plan of procuring a sufficient supply of comparatively pure drinking-water.

16. Distillation is a process by which ordinary well or mineral waters (hard waters) can be purified; but this is an expensive and tedious process, and is not practicable when large quantities are required; and further, distilled water must be aerated to render it fit for drinking purposes.

17. Boiling expels gases, precipitates lime, and destroys most animal and vegetable life that water may contain. Temporary hardness in water may be removed by boiling. Many waters possess both a temporary and a permanent hardness, and while they are improved by boiling, are not rendered perfectly soft. The boiling, to be effective, should be continued half an hour or longer. In unhealthy districts, or during epidemics, it is a wise precaution to drink none but boiled water.

18. Freezing purifies water by expelling a large portion of its mineral matter, such as carbonate of lime, etc. Distillation, boiling, or freezing of water renders it insipid by expelling air; but on standing for a time, the water regains its palatability.

19. Water Examined by the Senses. — The unaided senses are not always to be relied upon in the detection of impurities in water. It is only in extreme conditions that impurity can be detected by its taste or odor. Organic matter, for instance, when dissolved is often quite tasteless; and water may be transparent and odorless, and yet

contain impurities that are imperceptible by the senses. As information obtained in this way is necessarily very limited and unreliable, it is best to intrust the examination of water to a competent person whenever, from effects, it is suspected of being impure.

20. Temperature of Water-Supply.—The wholesomeness of water depends greatly upon its temperature. The fact has been pointed out that any increase in the temperature beyond 55° renders the water unwholesome. Until the water delivered to a certain town reached over 60° of constant temperature, diarrhœa did not break out in that town. During the following summer, the temperature of the water was five degrees less, and diarrhœa prevailed only in a slight degree. From a sanitary point, the temperature of drinking-water is extremely important.

21. *Cooling of water* supplied in cities is, in summer, generally effected with ice. But when ice is not obtainable, water in any ordinary earthen or stone pitcher, or other vessel, can be reduced several degrees in temperature by evaporation, in the following way:—

“Place several folds of linen or cotton cloth around the vessel, wet them as often as they become dry, and the constant evaporation will gradually abstract the heat of the water within the vessel. The more porous the vessel is, the more rapidly will the water cool.”

CHAPTER XX.

DRINKS (*continued*). — NARCOTICS AND STIMULANTS.

1. **Artificial Drinks.** — All drinks may be divided into two classes; viz., *natural* drinks and *artificial* drinks. To the first of these belong water and milk; and to the second, *tea, coffee, cocoa*, and the various *alcoholic beverages*. The artificial drinks are employed, in general, for nervous stimulation rather than for any nutritive properties of their own, and not because they relieve thirst more effectually than the natural drinks. While some artificial drinks may be useful when taken with care, yet they are extremely liable to prove very injurious to health when too freely used.

2. **Tea.** — On being analyzed, tea is found to contain (1) a volatile, essential oil which gives tea its agreeable aroma; (2) a vegetable alkali, called *theine*, which is nitrogenous and is the active or stimulating principle of tea; (3) *tannic acid*, which produces an astringent effect upon the bowels, but not usually to a harmful extent; and (4) gluten, salts, etc., which are not commonly obtained in the beverage. The varieties known as green teas and black teas differ only in the mode of drying the leaf. In China, tea is seldom used till it is a year old because of the well-known intoxicating properties of new tea. "Tea-tasters," engaged regularly in testing the quality of tea by its aroma and flavor, frequently complain of head-ache and giddiness; and persons engaged in packing teas for a few years are liable to attacks of paralysis, it is said.

3. Some authorities have over-praised the dietetic and medicinal values of tea, while others have declared it to be the source of diseases, especially of the nervous system. When the decoction is not too strong, it usually acts as a gentle stimulant upon the nervous system, and invigorates without producing subsequent weakness or depression. If it is taken in excess, it is apt to cause nervous wakefulness and indigestion. As a rule, tea is injurious to young persons, and is not a suitable drink till youth is completed. Adults of an irritable, nervous temperament often suffer from its use. "Old and infirm persons usually derive more benefit and satisfaction from it than from any other corresponding beverage." Tea proves a useful sedative in certain forms of heart disease, while in others it acts injuriously. The persistent use of strong tea for the purpose of keeping awake (a practice adopted by some students and by other persons) is certain to result in a loss of both bodily and mental vigor.

4. **Coffee.** — Coffee, like tea, contains a volatile oil which gives it a peculiarly agreeable aroma; a vegetable alkali (*caffein*) almost identical in composition with theine of tea, to which it owes its exhilarating power; and tannic acid, though in smaller quantity than tea. It also contains sugar, gum, and salts; but these latter substances do not enter largely into the beverage. The effects of coffee are similar to those of tea, and what has been remarked of tea applies to coffee as well.

5. Tea and coffee, although they are not positive foods, appear to retard the waste of tissue; and if the waste be lessened, the necessity for food to repair that waste will be diminished proportionately. If, however, they are relied on to supply by their stimulus the place of positive

food, they produce nervousness and dyspepsia. In a description of experiences during Arctic exploration, Dr. Hayes makes the following statement: "The men seemed to grow hungry less rapidly after taking coffee than after drinking tea, while the tea soothed them after a day's hard labor, and the better enabled them to sleep. They both operated upon fatigued and over-taxed men like a charm, and their superiority over alcoholic stimulants was very marked."

6. Cocoa. — Cocoa or chocolate is prepared from the ground seeds of the fruit of the cocoa palm. It contains a substance (*theo-bromine*) very similar to, but not identical with, theine or caffein. Cocoa contains also from 45 to 49 per cent of fat, and from 14 to 18 per cent of nitrogenous matter (albumen, starch, and sugar). While not so stimulating as tea or coffee, it will be understood from its composition that cocoa may be classed among the most nutritious foods. But few foods appease hunger better, or give greater nourishment, than a beverage prepared from cocoa and milk; and an eminent physiologist says, "It is equally good for all ages, classes, and circumstances."

7. Adulterations of Tea, Coffee, and Cocoa. — *Tea* of all varieties is often adulterated in one or more of the following ways: (1) Inferior varieties are mixed with the better kinds; (2) Exhausted leaves (*grounds*) are dried and mixed with fresh leaves; (3) the leaves of other plants (particularly those of the willow, elder, and beech) are mixed with the tea leaves; (4) green tea is sometimes tinted with indigo, Prussian blue, turmeric, or gypsum; and a bright-green tea should be suspected of adulteration, as the pure article is of a dull-green color; and

(5) black tea is sometimes tinted with graphite (black lead).

8. *Coffee*, when unground, cannot be adulterated easily; but ground coffee in packages is almost always adulterated—often, in fact, is not coffee at all. Package “coffees” usually consist of a very small quantity of the genuine article adulterated with chicory, pease, wheat, acorns, and corn. As these latter grains cost much less, the temptation to mix them with coffee is very great.

9. *Chocolate* and *cocoa* are often adulterated by the addition of too much sugar, or with starch, cinnamon, etc.

10. **Alcoholic Beverages.**—Alcoholic beverages include all those liquids that owe their stimulating and later narcotizing effects to the *alcohol* they contain. In speaking of the use of alcohol as a beverage, we do not mean that it is used in a pure state at any time.

11. *Alcohol* is the product of the decomposition of some form of saccharine matter, by means of *fermentation*. Both sugar and starch are vegetable products, and the latter is readily modified in composition so that sugar is produced from it. Sugar and starch may therefore be regarded together as the source of alcohol. Various fruits, grains, and tubers, such as the apple, grape, corn, rye, potato, and beet, yield sugar and starch abundantly.

12. *Fermentation* is the chemical process by which sugar, when subjected to the proper degree of temperature, is decomposed, and alcohol and carbonic acid gas are produced. Thus, the juice of apples kept at a temperature of 70° Fahr. undergoes a change in which bubbles of gas arise to the surface, the sugar of the juice is changed to alcohol, and a marked difference in the odor and the taste of the juice ensues.

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13. When grain is moistened and kept in a warm place, it begins to grow; and when chewed is found to taste sweet, part of the starch having been changed to sugar. By adding warm water and yeast to the grains, the sugar thus formed will ferment and produce alcohol and carbonic acid gas, as in the fermentation of apple juice.

14. The Fermented Liquors in common use as beverages are *cider*, *wine*, and *beer*:—

Cider is fermented apple juice, and contains from 1 to 15 per cent alcohol.

Wines are principally derived from the fermented juice of grapes, although other fruits are sometimes used in the manufacture of domestic or “home-made” wines. All wines contain alcohol, sugar, vegetable acids, and some of them contain *tannin* derived from the skin of the grape. The quantity of alcohol varies from 5 to 25 per cent in the different kinds of wine. Stimulating beverages called wines have been known by all nations and in all periods of the world’s history, and have been used and allowed to abuse from the earliest times of which we have any record down to the present day.

Beer is made from fermented infusions of grains or malt, flavored with hops. The amount of alcohol contained in the various kinds of beer and ale varies from 3 to 10 per cent.

15. The Distilled Liquors in common use as beverages are *brandy*, *whiskey*, *gin*, and *rum*. These are produced by distilling fermented liquors, the alcohol they contain having been formed during the process of fermentation. *Distillation* consists in the separation of any two liquids that boil at different degrees of temperature. As alcohol boils at 173° F., and water at 212° F., if a mixture of

the two be kept at a temperature above the boiling point of the former and below that of the latter, the alcohol will pass off in volatile form, accompanied by some vapor of the water. The vapory products thus driven off by heat are condensed, by conducting them through coils of cold pipes. The liquid thus obtained contains all the alcohol, a part of the water, and the volatile oils of the fermented liquors, and hence is much stronger than the latter. By repeated distillations, alcohol that is almost absolutely pure is obtained : —

Brandy is produced by distilling wine. It is colorless at first, but soon acquires an amber tint from the tannic acid of the casks. All dark brandy is artificially colored. New brandy contains from 50 to 60 per cent of alcohol.

Whiskey is usually made by distilling malted barley, though rye and other grains are also employed. It contains from 50 to 60 per cent of alcohol.

Gin is obtained by distillation of unmalted grains, and is flavored with juniper berries. It ordinarily contains somewhat less alcohol than brandy or whiskey does.

Rum is the product of the distillation of fermented molasses and skimmings of sugar boilers. It contains alcohol to the amount of 60 to 70 per cent.

16. The wines contain some free sugar, essential oils, and coloring matter from the fruits. Beer holds in solution sugar, dextrine, certain bitter essences, carbonic acid, etc. Brandy, whiskey, gin, and rum contain more or less sugar and certain volatile oils derived from the grains. It is the *alcohol*, however, in all these liquors that gives them their peculiar, stimulating, intoxicating, or noxious effects when used as beverages. If the alcohol they contain were removed, the remaining constituents would not ren-

der these liquors especially attractive. Many other artificial beverages are much more agreeable to the taste and produce greater tonic effects than the alcoholic liquors.

17. *Adulteration of alcoholic beverages* is very common, and so extensive as to make purity the exception. "While adulteration of alcoholic beverages is so extensive, the subject is more alarming from the character of the substances so shamefully employed, and from their effects upon the human system. However questionable the effects of alcohol itself, there can be no doubts as to the evil consequences to follow from the violent poisons employed in its adulteration." Certain publications devoted to the interests of manufacturers of and dealers in alcoholic liquors, give specific directions for modifying wines, beers, and distilled liquors, giving them color, flavor, etc., by the use of such substances as opium, aloes, nux vomica, tobacco, arsenic, strychnia, sugar of lead, white lead, red lead, logwood, copperas, and alum.

18. **Alcohol and its Properties.** — Alcohol, produced by the processes of fermentation already described, is a colorless liquid having an agreeable odor and a hot, pungent taste. It is lighter than water, very volatile, and highly inflammable. When ignited, its burning is accompanied by a very hot, blueish, smokeless flame. It possesses peculiarly important solvent powers, and readily dissolves gums, resins, and oils; it is therefore a highly useful agent in extracting these substances from leaves, seeds, barks, and roots. Many alcoholic tinctures containing the essential oils, or other medicinal elements of vegetable substances, are thus formed. It is largely used in the arts and sciences for similar purposes. As alcohol does

not freeze, it is employed in spirit-levels, and in thermometers for very low temperatures.

19. One of the most remarkable properties of alcohol is its *affinity for water*, the two uniting and being held in solution in each other in any proportion. It greedily absorbs water from organic substances, and preserves animal matter immersed in it from decomposition. Its antiseptic properties are equalled only by those of arsenic, creosote, and carbolic acid.

20. Like other narcotics, alcohol tends to allay pain when taken into the system, and this it does by deadening the sensibility of the brain and nerves, to which it is carried by the blood in its circulation. But as powerful as its proper use may be for good, the terrible results that follow its abuse, when it is used as a beverage, have caused many physicians to seriously question the advisability of prescribing it, the liability to become addicted to habitual alcoholic drinking being very great.

21. **Alcohol as a Beverage and as a Poison.** — A true beverage supplies the large amount of water needed by the tissues, without introducing any noxious element with it, and allays thirst. Substances which have great affinity for water extract it from the tissues when introduced into the body, tending thereby to cause shrinkage, hardening, and stiffening of such parts as are in contact with them. By absorbing water from the tissues they create thirst.

Dilute alcohol, as in the various alcoholic drinks, acts in this manner. In its strongest form, alcohol taken into the mouth or stomach will blister the mucous membrane and disorganize the structure of other tissues, so great is its affinity for the water contained in them.

In a similar way, only in less degree, any form of dilute

alcohol inflames tissues and produces thirst, while a true beverage always tends to allay thirst. It is true that the large amount of water in beer enables it to slake thirst; but it is also true that the water of the beer would assuage thirst more readily in the absence of the alcohol.

22. It is the function of the blood, so largely composed of water, to hold the food particles in solution. Alcohol, other than in very small quantities, arrests the digestion of food by hardening the albuminous particles and rendering them incapable of solution. In this action it is again the reverse of a true beverage.

23. Acting as a poison in dram-drinking, alcohol paralyzes the nerve centres, causes disease of the kidneys and liver, destroys digestion, deteriorates the blood, and invariably leads to chronic alcoholism and premature death.

24. When a considerable quantity of alcohol is taken during or after a meal, instead of aiding digestion it separates the pepsin from the gastric juice, and thus completely arrests digestion and causes immediate distress. If this is continued for a short time the function of the stomach is seriously interfered with. When it is taken before the day's labor begins, it does absolute harm. "Both body and mind will be incapacitated, the life shortened, and all the keenest joys taken out of what remains."

25. Of the moral effects of the abuse of alcohol, and of its special action on various organs and their functions, we have written in other chapters. That it inflicts untold misery upon thousands besides its immediate victims, no one will deny.

CHAPTER XXI.

DIGESTION. — MASTICATION, INSALIVATION, AND DEGLUTITION.

1. **Digestion.** — Digestion is a complex process, and is one of the chief of the organic functions concerned in the maintenance of life. It is that process, or, rather, series of processes, by which food is modified, or undergoes various changes which prepare it for appropriation by the tissues and structures of the body ; or, in other words, for conversion into blood. Perfect digestion and nutrition imply assimilation of nutrient material to the bodily structures without excitement or disturbance of any kind. There can be nothing of greater importance to physical well-being, and hence to the attainment of long life, than good appetite and good digestion, the two evidences of a healthy digestive apparatus. The immortal dramatist causes Macbeth to say : —

“ Let good digestion wait on appetite,
And health on both.”

2. In the words of Dr. J. G. Richardson, “If we consider the amount of ill-temper, despondency, and general unhappiness which arise from want of proper digestion and assimilation of our food, it seems obviously well worth while to put forth every effort, and undergo any sacrifice, for the purpose of avoiding indigestion, with its resulting bodily ills ; and yet, year after year, from the cradle to the

grave, we all go on violating the plainest and simplest laws of health, at the temptation of cooks, caterers, and confectioners, whose share in shortening the average term of life is probably nearly equal to that of the combined armies and navies of the world.”¹

3. Organs and Processes of Digestion.—The *digestive apparatus* is one of the most complex and extensive in the body. The *organs of digestion* are:—

1. The *mouth*, and its appendages—the *teeth*, *tongue*, *salivary glands*, etc.

2. The *pharynx*.

3. The *oesophagus*.

4. The *stomach*, *liver*, and *pancreas*.

5. The *intestines*.

6. The *absorbents*,—*lacteals*, etc.

The spleen and kidneys are appendages of the digestive apparatus, but belong rather to the circulatory or excretory system. The organs of digestion are situated mainly in the abdomen.

4. Beginning at the mouth, these organs, together with the passages that connect them, form a long, muscular, membranous tube, called the *alimentary canal*, which in adults is from twenty-five to thirty feet in length, and extends throughout the trunk. It is lined throughout with firm, delicate tissue, similar to that of the internal cavities in general, and known as the *mucous membrane*. Besides the digestive juices which it secretes, it sends out a glutinous fluid, called *mucus*, which moistens and protects the delicate lining, and enables its opposing surfaces to glide smoothly upon each other when brought in contact by the movements of digestion. The middle coat of

¹ “*Long Life and How to Reach It*,” in AMERICAN HEALTH MANUAL.

the canal consists of two sets of muscular fibres, one of which surrounds the tube like a series of rings, while the other extends longitudinally, or in the same direction as the tube itself, be it œsophagus, stomach, or intestine.

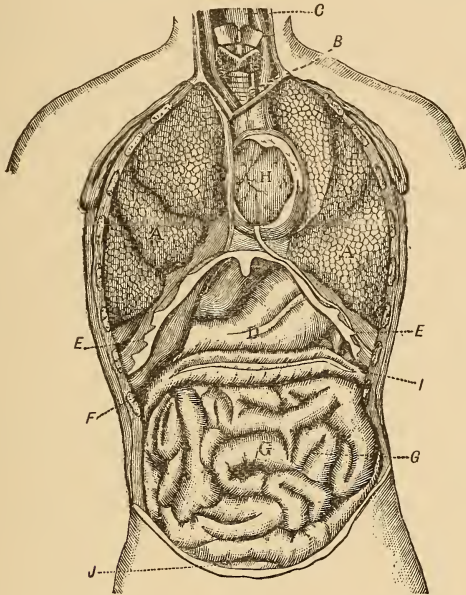


Fig. 39.

This figure represents the organs of the chest and abdomen in natural position, the breast-bone and ribs being removed.

EXPLANATION.

B, the trachea or (windpipe).
C, œsophagus or (gullet).
E, diaphragm.
F, liver.
I, spleen.

D, stomach.
G, intestines.
H, heart, the pericardium being laid open.
A, lungs.
J, bladder.

The outer coat is smooth and soft. The various portions of the canal differ in form, size, and general structure.

5. Finally the stomach and other organs situated in the abdomen are invested by a sac-like membrane, the *peritoncum* (Gr. *peri*, around; *teinein*, to stretch), which attaches them to the vertebral column and to the walls of the abdomen upon which it folds back and which it lines. That part of the fold behind the intestines fastens itself to the front of the vertebral column, and is called the *mesentery* (*mesos*, middle; *enteron*, intestine).

6. The *processes of digestion* may be classed as follows:—

1. Mastication,
2. Insalivation,
3. Deglutition, or swallowing,
4. Chymification, or stomach digestion,
5. Chylification, or intestinal digestion,
6. Absorption of the chyle.

7. All of these processes are important, and each of them must be properly conducted in order to maintain a healthy condition of the body. If any one of them is carried on imperfectly, the others, so intimately related and dependent, will be affected. We now proceed to a consideration of the various acts of which the digestive function is made up.

8. **Mastication.**—The operation of mastication, performed by the teeth and aided by the action of the tongue, cheeks, etc., is of the highest importance, since the more the food is broken down the more easily will the saliva and other digestive fluids mix with it in the digestive processes. The cavity of the mouth is bounded by the palate or roof of the mouth, and in other directions by the cheeks, lips, and tongue. Projecting into the cavity

above and below are the teeth of the upper and the lower jaw. The upper jaw (and consequently the dental arch which forms a part of it) is immovable, or can be moved only with the entire head. The lower with its teeth is capable of movement, by means of the powerful muscles of mastication, in five directions, viz., upwards, downwards, backwards, forwards, and laterally. By the varied movement of the lower jaw, the lower teeth grind the food against the upper, while the tongue and cheeks roll it about and keep it in place ; and thus the food is broken down or masticated.

9. The forms of the various classes of teeth fit them for the several processes of dividing the food. The front incisors, or cutting-teeth, are sharp on the edges for the purpose of dividing the food into smaller portions ; the cuspids, or eye-teeth, which project a little beyond the others, grasp the food more firmly ; the bicuspid, next in order, and having two prominences on their points, break the food into finer particles ; and lastly, the molars, or grinders, reduce and crush the food into a pulpy mass.

10. Mastication is the only digestive process that is entirely or directly under the control of the will ; and hence, an individual can "do more toward preventing dyspepsia and other disorders of the digestive apparatus by giving proper attention to the mastication of his food than in almost any other way." A glance at the anatomical structure of the teeth should alone be sufficient to impress the observer with the importance of "eating slowly and chewing deliberately."

11. In commenting upon a curious controversy as to the need or value of "biting one's food," the *Lancet* says : "Strange as it must appear, there are some, who should

be authorities, ready to affirm that it is futile to take the trouble to use the teeth with which nature has provided man, in common with other animals, apparently for the purpose of cutting and grinding his food. . . . Meanwhile, we counsel all who care for their comfort, and who do not desire to develop the worst form of dyspepsia, to continue the practice of mastication as before. As a matter of fact and experience, a liberal use of the teeth in feeding is one of the essentials in easy digestion ; . . . first, to divide the food and crush its fibres and particles generally ; and secondly, to mix it so thoroughly with the secretion from the salivary glands that not only shall the act of deglutition be rendered easy, but that the food when it enters the stomach shall have been properly prepared for digestion in the gastric juice."

12. It is certain that, since the stomach has no teeth, it was not designed to masticate food ; and it is obvious that the preservation of the natural teeth is one of the most important considerations in the personal care of the health.

13. Insalivation. — No part of the digestive process is more important than the insalivation and thorough mastication of food in the mouth ; and yet, by many people, these processes are seldom regarded or appreciated. All realize the necessity of moistening dry food when it is received into the mouth ; and if this were the only office to be performed by the fluid secretions of the mouth, the substitution of tea, coffee, water, and other liquids instead, for the purpose of moistening food, might be admissible. There are, however, other results to be produced ; and hence it is highly important that food be mixed with,

moistened by, and subjected to the chemical action of fluids which nature prepares within the walls of the cavity of the mouth. This natural moistening and mixing is termed *insalivation*.

14. The Salivary Glands and their Action. — Besides the numerous minute *buccal* glands which beset the mucous lining of the mouth, there are six distinct glands, three on each side of the cavity of the mouth, from which it receives its chief secretions. These pairs, called *salivary glands*, are composed of masses of tiny sacs, blood-vessels, and tubes held together by connective tissue, and are named, respectively, the *parotid*, the *submaxillary*, and the *sublingual* glands.

15. Each parotid gland is situated behind one of the angles of the lower jaw and forward of the ear. The duct through which it sends its secretion into the mouth passes forward along the cheek, and opens in its interior surface, opposite the second upper molar tooth. The parotid glands are the largest of the salivary glands.

16. The submaxillary glands are located just within the angles of the lower jaw, and their ducts open under the tongue, at its junction with the floor of the mouth.

17. The sublingual glands, which are the smallest of the salivary glands, are located under the tongue, beneath the membrane of the floor of the mouth, and their ducts open near the openings of the submaxillary glands. It is the office of all these glands to separate, or secrete, a fluid from the blood ; and their secretions, mingled with that of the small glands of the mucous surface of the mouth, constitute the *saliva*.

18. The presence of food in the mouth, or, often, the mere thought of food, excites the salivary glands to action ;

and the act of mastication further induces the flow of saliva. Hence, unless some portion of our food is of a solid consistence, and therefore requires thorough mastication, it does not become properly mixed with the saliva.

19. Nature and Action of Saliva. — The saliva is a colorless, turbid fluid, and, though thin and watery, it contains small quantities of animal matter which have very peculiar properties. Its reaction is alkaline, and the degree of alkalinity varies, being greater during and after meals. The daily average amount of saliva secreted by the glands of an adult man is estimated to be about three pounds or pints.

20. The action or use of saliva in the digestion of food is partly mechanical and partly chemical. Mechanically, it moistens dry food, and thus serves the double purpose of preparing it to be swallowed and of separating its particles so that they may be more freely acted upon by other digestive juices in the stomach and intestines. Besides moistening, it lubricates each bolus of food, and thus facilitates its deglutition. Chemically, the saliva acts upon the amylaceous or starchy portion of the food, and turns the starch into grape-sugar.¹ The great importance of this action of the saliva will be comprehended when it is understood that starch is insoluble as nutriment, and cannot be appropriated by the tissues and structures; while sugar is easily soluble and assimilable. Thus it will be seen that while water, milk, tea, coffee, and other liquids may be used to moisten food, none of them can be substituted for saliva without impairing digestion, as none of

¹ This chemical change is produced by the *ptyaline* of the saliva, an ingredient which acts as a ferment; that is to say, under favorable conditions of moisture and heat, "it changes the chemical constitution of a substance for which it has an affinity."

them have the property of changing starch into sugar. Saliva does not act upon proteid substances, nor upon the oils or fats of food-stuffs.

21. Tobacco and Salivary Digestion. — Chewing and smoking of tobacco exhaust the salivary glands of their secretion, thus producing dryness and thirst ; or the saliva, being tainted with tobacco, is rendered unfit for its office and is wasted. The starchy portions of the food which should be acted upon by the saliva remain partially unchanged. Those addicted to the excessive use of tobacco often have “a morbid running or drivelling from the mouth, not of true saliva, however, but of a depraved and acrid secretion (caused by over excitement and irritation of the glands), analogous to that of catarrh of the head and other morbid affections of the mucous membrane.” In this latter instance, the salivary glands become sewers, as it were, for the excretion of waste matter from the blood, and excessive thirst is produced.

22. Action of Acids on Salivary Digestion. — The influence of acids in retarding or arresting salivary digestion is of importance in the use of pickles, vinegar, acid fruits, etc. In the case of vinegar it has been found that 1 part in 5,000 sensibly retarded the process of converting starch into sugar, 1 part in 1,000 rendered it very slow, and 1 part in 500 arrested it completely. When, therefore, acid salads are eaten with bread, the effect of the vinegar is to prevent the salivary digestion of the starch of the bread ; this, to a person of vigorous digestion, may be a matter of little moment ; but to a feeble dyspeptic, one of some importance. The belief that drinking of vinegar is an effective means of avoiding or reducing corpulence appears to be well founded, especially if the vinegar be

taken at the same time as starchy food, as it will greatly interfere with its digestion and assimilation.

23. Deglutition. — Deglutition, or swallowing, is the act by which the food is transferred from the mouth to the stomach. After mastication and insalivation are completed, the tongue moves the mass backward into the *pharynx*, the funnel-shaped cavity which is located behind the mouth and at the first bend of the alimentary canal downward. Between the mouth and the pharynx is the soft palate, which is a movable muscular partition that separates the two cavities during mastication. As soon, however, as the food is moved backward by the tongue, the soft palate is drawn obliquely upwards and backward so as to close completely the passage between the pharynx and the nose, thus performing the part of a double valve, and permitting the food to enter the pharynx. (When the pendulous soft palate is destroyed by disease, both the swallowing of food and the tones of the voice are rendered more or less imperfect). Having arrived at the *œsophagus*, or gullet (the next portion of the canal, and continuous with the pharynx), the bolus of food is driven into it by the action of certain muscles called *constrictors*, which form the walls of the pharynx.

24. Whenever the act of swallowing is performed, the opening in the wind-pipe is closed by a valve (the *epiglottis*), and that into the nose by the soft palate, so that during this operation all ingress of air to the lungs is prevented; and consequently, it is necessary that the passage of food through the pharynx should be rapid. "All voluntary action ceases as soon as the food is passed into the pharynx, and it is necessarily carried on into the stomach, in spite of our will." Life depends upon the passage of the food

through the pharynx with extreme rapidity and the nicest precision.

25. The *œsophagus*, which connects the pharynx with the stomach, is about nine inches in length, and is located in front of the upper portion of the spinal column, and behind the wind-pipe. Like other portions of the alimentary canal, its muscles are of the involuntary kind, some of them surrounding it in a circle, while others run lengthwise. When these two sets of muscles contract together, they force forward the food within their grasp, and it is thus driven into the stomach. The act of deglutition is then complete.

CHAPTER XXII.

CHYMIFICATION, OR STOMACH DIGESTION.

1. **The Stomach.** — The stomach is a muscular bag, of an irregular oval shape, which is often compared to that of the air-bag of a bag-pipe. It is located transversely across the upper part of the abdomen; and while it varies in size in different persons, in the average adult it is capable of containing about three fluid pints.

2. The *œsophagus* opens obliquely into the left extremity of the stomach by an aperture called the *cardiac orifice*, so named because of its nearness to the heart. This orifice is guarded by a muscle surrounding it in a circular form, and which can contract so tightly as to prevent the passage backward of substances that have entered the stomach. At the right extremity, the stomach opens into

the *duodenum* by a small aperture, called the *pyloric orifice*, which is surrounded by a strong, circular muscle presenting the appearance of a prominent band, and called

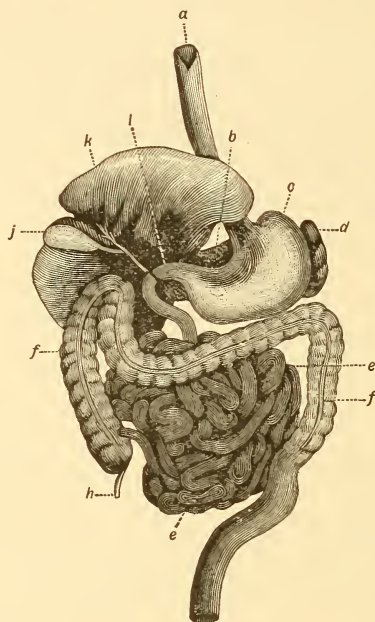


Fig. 40. The Organs of Digestion.

EXPLANATION.

a, the *œsophagus*.
 b, the *pancreas*.
 c, the *stomach*.
 d, the *spleen*.
 e, the *small intestine*.

f, the *large intestine*.
 h, the *appendix*.
 j, the *gall-bladder*.
 k, the *liver*.
 l, the *pylorus*.

the *pylorus* (Gr. *puloros*, a gate-keeper). The office of the pylorus is to guard the opening and prevent the exit of aliment while it is being digested in the stomach,

Between the two orifices are the two curvatures of the stomach, the upper one, called the *smaller*, and the lower one the *greater curvature*.

3. The *inner or mucous coat* of the stomach is thick and soft, and lies in irregular folds, termed *rugæ*, whose object is to enlarge the space for blood-vessels, nerves, etc. The rest of the thickness of this coat is chiefly made up of minute tubes running to the inner surface of the stomach; these are the *gastric tubes, or glands*, which secrete the gastric juice from the blood in the capillaries of the mucous lining.

4. The *middle, or muscular coat* consists of longitudinal muscular fibres and of circular ones. The contraction of these fibres diminishes the length and the diameter of the stomach; and hence, the food, acted upon by both sets of muscular fibres, is turned and compressed in various ways during digestion.

5. The *outer or peritoneal coat* is formed of a membrane already mentioned, the peritoneum, which, while retaining the stomach and intestines in place, permits their necessary movements.

6. **The Gastric Juice.** — The changes which the food undergoes in the stomach are due to the action of the *gastric juice*, the acid fluid which Dr. Beaumont saw exuding from the mucous membrane of the stomach of St. Martin.¹

¹ In 1822 a Canadian named Alexis St. Martin, employed by a fur-trading company, received a severe wound in the left side, by the accidental discharge of a gun. He was attended by Dr. Beaumont, and his health was finally completely restored, though, strange to say, there was left an opening into the stomach, about four-fifths of an inch in diameter, closed by a flap of membrane which could be pushed inward. Dr. Beaumont kept St. Martin in his employment for several years, made hundreds of observations upon him, noticed the effects of various kinds of food, and ascertained the time required to change it into chyme. "Dr. Beaumont was the first, and for many years the only, person who ever saw the interior of the stomach in a living

This fluid is colorless, slightly viscid, and invariably acid. Its two important or essential elements are *hydrochloric*

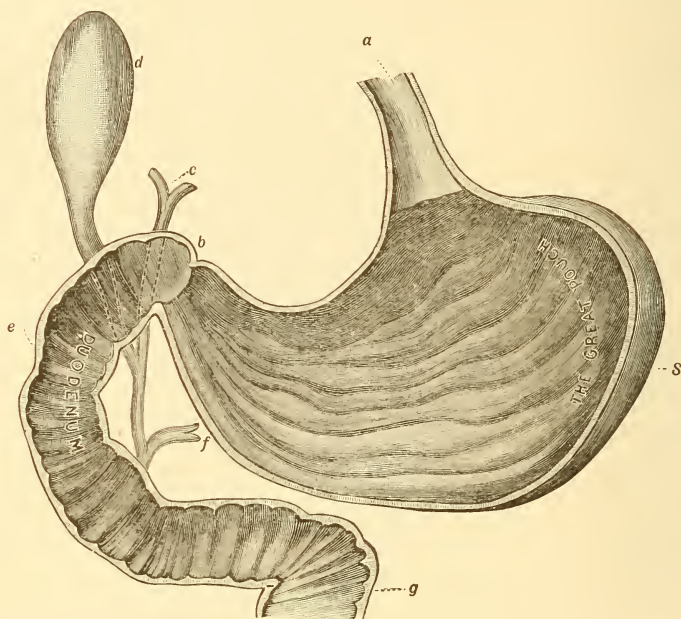


Fig. 41. The Stomach laid open in front.

EXPLANATION.

a, the *esophagus* or *gullet*; *b*, the *pylorus*; *c*, the *bile duct* extending from the liver; *d*, the *gall bladder*; *e*, the *duodenum*; *f*, the *pancreatic duct*; *g*, the *small intestine*; *S*, the *stomach*, showing the *folds* (or *rugæ*) of the inner coat or *mucous membrane*.

or lactic acid, and an organic ingredient which, on analysis, is found to be highly nitrogenous, and which is called *pepsin*. If the juice be deprived of these constituents,

man; and to his observations we owe much of our knowledge of stomach digestion. Experiments upon animals have also aided greatly in determining the laws of digestion."

it becomes incapable of performing its office in the digestion of food.

7. The gastric juice serves to dissolve and to transform the nitrogenous matters of food, such as albumen, fibrin, casein (lean meat, the white of eggs, the gluten of wheat, etc.), converting them into substances, termed *peptones*, which are in condition to be absorbed and to enter the blood. The gastric juice also releases fat from its envelopes, by breaking them up; but the best authorities agree that the gastric juice exerts no great influence upon the fat, sugar, or starch of food. It is supposed that saliva flows down into the stomach and acts upon starchy food that may have escaped action in the mouth.

8. The quantity of gastric juice secreted daily by an adult person averages about fourteen pounds; that is, about a gallon and a half. Dr. Beaumont remarks in his little book: "The gastric juice never appears to be accumulated in the cavity of the stomach while fasting. When aliment is received, the juice is given out in exact proportion to its requirements for solution, *except when more food has been taken than is necessary for the wants of the system.*"

9. **Stomach or Gastric Digestion.** — The stomach during chymification is a closed chamber; its cardiac orifice is closed by the valved entrance of the œsophagus, and its pyloric orifice by the contraction of the pylorus. The muscular coat contracts in a slow, regular manner, rolling and otherwise moving the contents of the stomach in a peculiar way, and thus mixing the food with the gastric juice.

10. The arrangement of the food in the stomach has been described as follows: "The food first received is

placed outermost, that is, nearest the inner surface of the stomach; the portion next taken is placed interior to the first, and so on in succession, until the food last taken occupies the centre of the mass. Soon after the food has been thus arranged, a remarkable change takes place in the mucous membrane of the stomach; the blood-vessels become loaded with blood, and the minute cells between the rugæ overflow with fluid, the gastric juice." Dr. Beaumont, who saw what he describes, says that the course and directions of the food on entering the stomach are first, from right to left and downward along the greater curvature towards the right, or pyloric extremity; it then moves along the smaller curvature, or upper surface of the organ, to its left extremity, each circuit requiring from one to three minutes.

11. In the food itself no change is manifest for some time; but at length, that portion of it which is in immediate contact with the mucous surface begins to be slightly softened. This softening slowly increases, and ultimately the most solid portions of the food are completely dissolved. The dissolved and detached portions flow toward the pyloric extremity of the stomach. The fluid which thus accumulates, slowly but steadily, is a new product in which the sensible properties of the food, no matter what the variety of its substances, are lost; all have been resolved into an homogeneous, grayish, slightly-acid fluid, called *chyme*.

12. As soon as the chyme, by its gradual accumulation in the pyloric extremity, amounts to about two or three ounces, the pylorus relaxes, opens, and permits the fluid to be squeezed or pressed through the opening into the *duodenum*, or first section of the smaller intestine. When

the duly prepared portion of the chyme has passed out of the stomach, the pylorus closes, and remains closed until another like quantity has accumulated, and then repeats its former action, renewing it again as long as this *process of chymification* continues.

13. The ordinary temperature of the interior of the stomach is 100° F. Cold liquids taken with food tend to lower the temperature, and hence to retard stomach digestion.

14. Absorption from the Stomach. — But do all the substances that are thoroughly dissolved in the stomach pass out of the stomach through the pyloric valve? As already intimated, a portion of the products of stomach digestion (consisting of peptone mixed with saliva and saccharine fluids) are at once absorbed through the walls of the numerous and delicate blood-vessels (capillaries) of the stomach, and pass out into the blood. “As the veins of the stomach, which are formed by the union of these capillaries, contribute to form the *portal vein*, the absorbed matters pass directly to the liver, and probably stimulate it to increased secretion,” etc.

15. Time required for Stomach Digestion. — The rapidity with which the chymification of food is carried on varies according to the digestibility of the food, the size of the morsels swallowed, the quantity received by the stomach, and the state of the health of the individual. In about five hours after an ordinary meal, all of the food taken is probably converted into chyme.

16. The foods which are soonest dissolved in the stomach are not necessarily the most nutritious; and it matters not whether a given aliment digests in two hours or in four, so far as its nutritive value is concerned. But those articles which require a long time for solution tax

the powers of the stomach severely, and, if it is not vigorous, such articles often prove absolutely indigestible. Speaking of delayed digestion, Huxley remarks: "If aliment is not absorbed into the system from the digestive apparatus, it rapidly undergoes chemical decomposition in the alimentary canal, and often putrefies."

Table giving the Length of Time required for the Digestion of a Few of the most Ordinary Kinds of Food.

ARTICLES.	CONDITION.	TIME.	
		Hours.	Minutes.
Pork, fat and lean	Roasted	5	15
Suet, beef, fresh	Boiled	5	30
Cabbage, with vinegar . . .	Boiled	4	30
Ducks, domestic	Roasted	4	00
Ducks, wild	Roasted	4	30
Cheese, old, strong	Raw	3	30
Eggs, fresh	Boiled hard . .	3	30
Eggs, fresh	Raw	2	00
Chicken, full grown	Fricassed	2	45
Bread, white	Baked	3	30
Potatoes, Irish	Boiled	3	30
Codfish, dry	Boiled	2	00
Soup, bean	Boiled	3	00
Soup, barley	Boiled	1	30
Rice	Boiled	1	00
Oysters, fresh	Raw	2	55
Apples, sweet	Raw	1	30
Dumpling, apple	Boiled	3	00
Beef	Fried	4	00
Beefsteak	Broiled	3	00
Veal	Boiled	4	00
Sausages	Broiled	3	20
Milk	Boiled	2	00
Milk	Raw	2	15
Custards	Baked	2	45
Soup, beef, vegetables . . .	Boiled	4	00

17. Alcohol and the Stomach. — The action of alcohol on the stomach is that of an irritant. Having great affinity for water, it absorbs moisture from the tissues with which it comes in contact, and thus tends to parch and dry them. In all except minute quantities, it inflames the stomach ; and when taken habitually, or in large quantities, it injures or destroys some of the glands which secrete the mucous and the gastric fluids, and thickens and toughens the mucous lining. It also reduces the sensibility of the nerves of the stomach, paralyzing them to an extent that tends to render nervous and muscular action of the stomach less vigorous, and thus interferes with the process of digestion.

18. In the case of St. Martin, Dr. Beaumont observed that “the free use of ardent spirits, wine, beer, or any other intoxicating liquors, when continued for some days, produced a state of inflammation and ulceration in the lining membrane, and change of the gastric juice ;” and Dr. Albert Day, an eminent writer and authority on alcoholic diseases, says : “There is no appearance, after death, more common in the confirmed drunkard, who perishes after a long continuance of this habit, than a state of chronic inflammation of the lining membrane of the stomach. In this condition the walls of the organ are sometimes considerably thickened, are covered in their interior with a net-work of vessels closely injected with blood, and may present more or less extensive traces of ulceration. The thickening of the coats of the stomach may proceed to such an extent as to interrupt the passage of food, through mechanical impediment.” It is evident, therefore, that the normal condition of the stomach of the habitual drinker of alcoholic liquids is greatly affected,

and hence that the functions and usefulness of the stomach are proportionately impaired by alcohol.

19. Alcohol and Digestion. — The Gastric Juice. — Alcohol when taken into the stomach excites a profuse flow of gastric juice; and as a large amount of gastric juice no doubt digests food more rapidly than a small amount, it has been argued that alcohol aids digestion by provoking an increased secretion of that juice. This may be its effect when taken in minute doses and during a limited period. But the secretion of gastric juice should be a natural process; it should not be the outcome of an extortion which involves exhaustion and waste. In the words of an eminent writer, "Alcohol, though apparently helpful at the moment by procuring a profuse flow of gastric juice, secures this temporary effect at the cost of great waste of this precious fluid." If alcohol is habitually taken, it constantly overtaxes the natural resources of the blood from which the gastric juice is derived, thus impoverishing the blood, and, consequently, degenerating the gastric juice and impairing digestion.

20. But furthermore, alcohol in the stomach absorbs water from the gastric juice and precipitates the pepsin, thus separating it from the juice.¹ Deprived in this way of much of its chief solvent principle, the gastric juice is more or less unfitted for its office. The gastric juice is incapable of altering alcohol, and the latter is absorbed by the vessels of the stomach and passes into the blood unchanged.

¹ Take the stomach of a calf or of a pig that has just been killed, rinse the gastric juice out of it with a very small quantity of water, and put the liquid into a small bottle. The liquid will be milk-white, and, *if a small quantity of alcohol is poured into it*, the white portion will settle to the bottom. This white sediment contains the *pepsin*.

21. In other than very small quantities, it arrests the digestion of albuminoid food by shrinking and toughening it, thus rendering it insoluble. As the chemical action of alcohol on organic substances retards change in them, and because of its effects on the gastric juice and the nerves and muscles of the stomach, imperfectly digested food will pass through the pyloric valve into the small intestine. It follows, therefore, that the habitual drinking of alcoholic liquors impairs digestion; and impaired digestion often becomes chronic indigestion with its numerous train of diseases,—inflammation of the stomach and of the bowels, diarrhœa, constipation, etc.

22. Alcohol and Thirst. — It is well known that thirst is “an unfailing sequel” to the drinking of alcoholic liquor. In this fact we have proof that alcohol is not a true beverage. All true beverages furnish water to the blood and tissues, and thus slake thirst. Alcohol, on the contrary, absorbs water from the tissues, and produces thirst. It is true that beer and other beverages which contain a large amount of water and a small quantity of alcohol allay thirst to a considerable extent; but the water of these drinks would quench thirst more readily in the absence of the alcohol.

23. Alcohol and the Accumulation of Fat. — The maintenance of perfect health requires that certain constructive and destructive changes shall take place in the body with perfect regularity and uniformity. In the words of Dr. Yeo, “If there is a disturbance in the constructive changes, the fabric suffers, and loss of strength must follow; if there is disturbance of the destructive changes, the injury to the health of the body may not be so immediately apparent, but it will be felt, sooner or later. Mere excess

of food, or an improper method of feeding, may be the cause of some of these disturbances. Thus it is easy to understand how corpulence arises. Something is regularly taken into the system which is not needed for construction or maintenance. If this excess were got rid of in a regular and normal manner, nothing remarkable would arise. But in some organizations there is a tendency not to turn this excess into substances which can readily be discharged from the body, but to throw it aside, as it were, within the body in the form of fat."

24. It is true that certain persons who habitually drink alcoholic beverages which contain saccharine matter increase in fat and weight. But the fat in such instances is formed of particles of aliment which have been alcoholized, and which, while not adapted for use in the body, have not been reduced to a form in which they can be excreted from it; hence they are held in the form of fat by the tissues. True nutrition is a replenishment of the tissues, and is not a mere accumulation of fat. Excessive accumulation of fat is a disease; and when the fattening process extends, as it often does, into the interior of the body, there are produced the diseases known as *fatty degeneration* of the heart, liver, kidneys, etc.

25. The fat of the beer-drinker is not so much an indication of healthful nutrition as it is of deficient excretion. Excessive fat adds no strength to bone, nerve, or muscle. In appearance the beer-drinker may be "a picture of health," but in reality he is most incapable of resisting disease. Fatty deposits, diminished circulation, congestions, and disturbance of the functions of the stomach, liver, and kidneys, are, one or all, commonly present. Injuries, which to another would be but trivial

in results, are apt to lead to serious complications in him ; and when it is necessary to perform surgical operations upon the habitual drinker, the risk of a fatal result is much greater than in the case of a temperate person.

26. Effects of Tobacco upon Digestion. — Chewing and smoking of tobacco overtask the salivary glands, and both vitiate and exhaust their secretion. The digestive process dependent upon the action of the saliva must be greatly retarded in consequence of the great waste of that fluid, caused by its being expectorated from the mouth. The poisonous nicotine is absorbed by the mucous membrane of the mouth, stomach, etc., and enters the blood, producing nausea and prostration.

27. The alimentary canal suffers by the greater or less quantity of tobacco juice swallowed with the saliva, in either smoking or chewing the weed, producing loss of tone in the stomach, failure of appetite, indigestion, and constipation. Its poisonous property is due to the active principle, *nicotia*, which in its free state is an extremely powerful and deadly poison, “proving fatal sooner than any other excepting prussic acid.”

28. Like alcohol and other narcotics, tobacco begets a depraved appetite to which the strongest wills yield and become enslaved. It attacks the blood, increasing its fluidity and causing resistance to coagulation. Its vitiating effects upon the blood result in harm to the brain and nerves ; and nervousness, languor, disturbed sleep, and mental depression are common effects of its action on the nervous system.

CHAPTER XXIII.

CHYLIFICATION, OR INTESTINAL DIGESTION.

1. **Difficulty of Investigation.**— We now follow the progress of the chyme from the stomach into the intestines, and note the changes that are effected in it, which are collectively known as *chyliification*, or intestinal digestion.

2. The opportunities for observation or investigation of the digestive processes carried on in the intestines of human beings have been very limited, and are attended with great difficulties; and hence, comparatively little progress has been made towards ascertaining exactly how digestion is completed, the functions of various organs, and the action of the digestive juices. Almost all our exact knowledge of the intestinal processes has been obtained by experiments on animals.

3. **The Intestines.**— The intestines are continuous with the stomach, and form one long tube having mucous, muscular, and peritoneal coats like the stomach. The peritoneal coat is reflected off from the back of the tube, in its entire length, and attaches it to the spinal column by a double fold of membrane, called the *mesentery*. The intestinal tube is divided anatomically into the *small intestines* and the *large intestine*, the latter having a larger diameter than the former. The valve, or opening of the small intestine into the large one, is situated in the region of the right groin; and while it permits the passage of substances from the former into the latter, it opposes their passage in the opposite direction.

4. **The Small Intestine.** — The small intestine is subdivided into three parts, viz., the *duodenum*, the *jejunum*, and the *ileum*; but there is no actual line of separation between these, and the names indicate merely an arbitrary distinction made by the ancient anatomists.

5. The *duodenum* is that part of the small intestine which immediately succeeds the stomach, and it is so named because it measures nearly twelve finger-breadths in length. It is bent into a loop, and is fastened to the back wall of the abdomen.

6. The *jejunum* is the intermediate section of the small intestine, and its numerous coils occupy the central region of the abdomen.

7. The *ileum* is that section of the small intestine which opens into the large one by a valve (the *ileo-cæcal* valve) to which reference has been made. The length of the small intestine is about twenty-five feet.

8. **The Large Intestine.** — The large intestine is divided, for convenience of description, into three parts, called respectively the *cæcum*, the *colon*, and the *rectum*.

9. The *cæcum* is the pouch-like enlargement situated in the lower part of the right side of the abdomen, and into which the small intestine opens. Attached to the *cæcum* is a peculiar, slender, projecting tube, which, from its form, is called the *vermiform appendix*, i.e., the worm-like appendage, and for which there is no known use. It is a constant source of danger from the fact that the small seeds of berries and other fruits occasionally find lodgement in it, causing irritation which results in the formation of an abscess and the destruction of life.

10. The *colon* constitutes the greater part of the large intestine. It is subdivided into three sections, viz., the

ascending colon, which rises from the cæcum and extends upward on the right side of the abdomen, nearly to the stomach; the *transverse colon*, which extends, across toward the left, below the stomach; and the *descending*

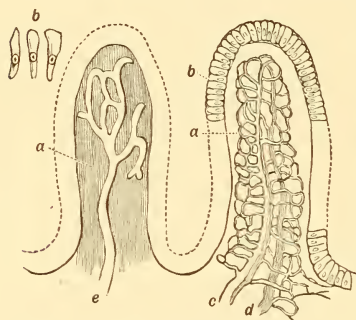


Fig. 42. Semi-diagrammatic View of Two Villi of the Small Intestines. (Magnified about 50 diameters.)

EXPLANATION.

a, substance of the villus; *b*, its epithelium, of which some cells are seen detached at *b* 1; *c* *d*, the artery and vein, with their connecting capillary network, which envelops and hides *e*, the lacteal, which occupies the centre of the villus and opens into a network of lacteal vessels at its base.

colon, which extends downward on the left side. Reaching the middle line, the colon becomes the *rectum*, which is the last division of the large intestine and the termination of the intestinal canal. The length of the large intestine is about five feet.

11. The Interior of the Intestines. — The mucous coat, or lining of the intestines, is thrown into numerous shelf-like folds, which, from their winking or wave-like motion in the fluids of the intestine, are called *valvulæ conniventes*. These folds or

valves form arches which encircle about three-fourths of the intestine, and are of use in retarding the passage of food along the canal, thus affording the absorbent vessels a better opportunity to imbibe nutritious matter. They also increase the extent of the secreting and absorbent surface. The mucous coat is penetrated almost to its surface by minute blood-vessels and absorbent vessels, which, in many places, are covered only by a very thin layer of delicate membrane.

12. Upon the surface of the mucous coat are almost innumerable hair-like projections which present a plush-like appearance, and are known as *villi* (L., meaning *closely set hairs*). The estimated number of these is about 10,000,000. Each *villus* contains numerous little blood-vessels, which doubtless absorb certain fluid products of digestion and empty them into the *portal vein*, by which they are conveyed to the liver and thence to the heart.

13. **Lacteals.** — In the interior of each villus are also the finest twigs of one or more *lacteals* (L. *lac*, milk) — ves-

EXPLANATION.

A portion of the *thoracic duct*, marked T D above, and T D below, lying in front of and in contact with the *spine*, S.

By the side of I I, is seen a portion of *intestine* attached to the *mesentery*, a kind of *membranous ruffle*, around the border of which the entire tube of the *intestine* is fastened.

L L show a *lacteal vessel* running from the inside of the *intestine*, charged with a milky fluid which is conducted into the *mesenteric glands*, seen lying between the two folds of that membrane. In these the chyle is essentially changed in character, and perhaps receives additional fluid from the gland itself. From these the fluid next passes on through the *excretory ducts*, M M, which join the main trunk of the *thoracic duct*.

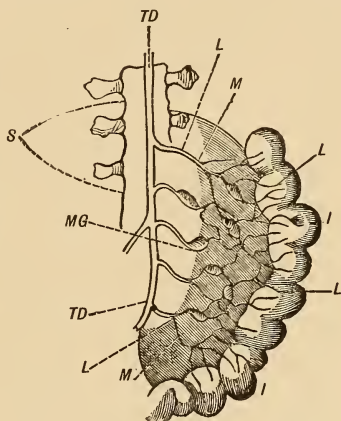


Fig. 43.

sels having club-shaped, and probably closed, extremities. The lacteals are absorbent vessels belonging to the great system of *lymphatics* which are found everywhere in the body. The milk-white appearance of the lacteals, when filled with the digested matter which they absorb from the canal, suggests their name. These vessels combine with each other, and form a network from the meshes of which proceed branches. These branches, successively

uniting, form larger trunks which finally pass out through both mucous and muscular coats, and, after again uniting, terminate in a small oval sac, called the *receptaculum chyli* (receptacle of the chyle), which is situated in front of the vertebræ of the loins. From this sac the *thoracic duct*, "a tube quill-like in size," extends upwards in front of the spinal column, and opens into the left subclavian vein (the large vein under the left collar-bone), pouring its contents into the venous blood just as it is about entering the right side of the heart.

14. Intestinal Glands. — In the mucous coat of the intestine are numerous *glands*, some of which secrete and pour out mucus, and others digestive fluids. These secretions combine to form what is termed the *intestinal juice*. Into the duodenum two peculiar fluids are conveyed by a common duct, one of whose branches brings in *bile* from the liver, and the other the *pancreatic juice* from the pancreas.

15. The Liver. — The liver is the largest gland of the body; and it weighs, in health, from three to four pounds. It secretes from the blood a bitter fluid called *bile*, which, during the intervals of digestion, is stored up in the *gall bladder* upon the under side of the liver. While the liver is evidently a very important organ, still its precise use and functions are not well known, and are subjects of dispute and doubt. The special office which the bile performs in relation to digestion is even yet a controverted point. Animals have been subjected to operations which, while not interfering with the action of the liver, prevented the bile from entering the intestine. It was found that, although the appetite and digestion of animals thus treated remained good, yet they soon became emaciated

and died of apparent starvation. This fact has led to the conclusion that the bile performs some specially important office in the nutrition of the body, and is not merely an excrementitious fluid to be discharged from it.

16. It is also believed that the liver secretes sugar from the fluids of the portal vein, and that this sugar is decomposed and disappears in the process of nutrition.

17. **The Pancreas.**—The *pancreas*, or *sweet-bread*, is a gland about six inches long, and is situated behind the stomach. It secretes the pancreatic juice, which by experiment has been proven to be a chief agent in the digestion of fatty portions of the food, breaking them up into minute particles which are in condition to be absorbed by the vessels of the intestine.

18. **The Spleen.**—This is a spongy gland situated at the left extremity of the stomach, just under the false ribs. It has remained an unsolved puzzle to physiologists, and its office remains to be discovered. It is a remarkable fact that the spleen may be entirely removed from a dog without lasting injury to his health. A large artery supplies the spleen with blood, and its veins empty into the portal vein, and thence into the liver. A recent and plausible supposition is, that the spleen may be employed in the formation of new blood corpuscles, and in the destruction of old ones.

19. **The Kidneys.**—These are two bean-shaped glands, each about four inches long, two and a half broad, and one and a half thick, situated in the region of the loins, one on the right and the other on the left of the spinal column. They consist of a multitude of fine tubes and blood-vessels invested by connective tissue. Large arteries enter the kidneys, and it is their function to purify the

blood by removing from it a poisonous substance, called *urea*, and certain salts and surplus water. These waste products are conducted from the kidneys to the bladder by two tubes, called *ureters*, each about equal to a goose quill in diameter and twelve to fifteen inches long. The kidneys are subject to many forms of disease, and a suppression of their secretion, unless quickly relieved, results in poisoning of the blood, stupefaction, and death.

20. Chylification. — The function of the small intestine is more than a merely mechanical one. The process of digestion, begun in the mouth and carried on so actively in the stomach, is here continued. In a physiological sense, the duodenum may be regarded as a second stomach, the jejunum as a third, and it would scarcely enter the field of imagination to regard the ileum as a fourth; for throughout the whole length of the small intestine the process of digestion goes on, a solvent fluid being secreted in varying quantities along its whole inner surface.

21. In the duodenum the chyme is mixed not only with the *intestinal juice*, but also with the *pancreatic juice* and the *bile*. The pancreatic juice probably completes the work of the saliva by converting into sugar such particles of starch as escaped digestion in the mouth, and also breaks up fatty matter into minute globules. The bile also, being alkaline, is believed to have an effect similar to that of the pancreatic juice in separating fatty substances into minute particles, and also that it neutralizes the acid contained in the chyme. The intestinal juice, secreted by millions of glands, is so mixed with the other digestive juices that but little is known of its special effects. It probably possesses a feeble digestive property,

and it is both affirmed and denied that this juice changes starch into sugar.

22. During digestion the various digestive fluids are secreted, poured out, and re-absorbed with great energy and in large quantities. No portion of the food can be absorbed except in complete solution, and such solution is effected by the chemical action of the digestive juices. Their nature, in combination, is *alkaline*; and by their united action the chyme is converted into a milky fluid, called *chyle*, which is readily absorbed into the blood.

23. **Absorption of the Chyle.** — The encircling muscular fibres of the small intestine contract from above downward, with a wave-like movement, and propel the chyle along the canal, being aided in this by the action of the longitudinal fibres. This action of the intestine is termed its *vermicular motion*, i.e., worm-like motion.

24. The *villi* projecting from the lining membrane of the intestine sway about in the chyle, and absorb, or (as recent researches seem to indicate) draw by a pump-like action, the creamy portions of the nutritious fluid into the ends of the lacteal vessels in their interior. Conducted by the lacteals into the *receptaculum chyli*, and from that sac by the thoracic duct into the left subclavian vein, the chyle is poured with the venous blood into the right side of the heart. The network of blood-vessels of the intestine also takes up and carries into the blood large portions of the chyle. On entering the heart, the chyle in conjunction with the venous blood is pumped into the lungs, and is there converted into perfect or arterial blood, "fit for the highest processes of organization."

25. Evils of Indigestion.—Certain portions of the food eaten are not capable of complete digestion, and, being insoluble, cannot supply the wants of the tissues. It is the function of the large intestine to secrete effete matters from the blood, and to expel these and the innutritious or waste portions of the aliment.

“When effete matter is retained a moment beyond the time its expulsion is demanded, the absorbents carry some of the more fluid portions of the poisonous mass into the circulation, and they become diffused throughout the body. The more solid portions, by pressure upon the small blood-vessels, cut off the circulation in them, causing painful engorgements known as hemorrhoids. But the trouble is seldom confined here. As a result of the blood-poisoning, there is almost invariably more or less dyspepsia, derangement of the functions of the heart, liver, and kidneys, accompanied by headache and nervous debility, often verging on paralysis.”

Suggested Points for Questions.

CHAPTER XVI.—1. Necessity of food—waste and repair. 2. Food as fuel—energy, life, repair. 3-4. Hunger and thirst—nature, indicative, time endured respectively. 5. A true food defined; carbon, hydrogen, oxygen, and nitrogen as elements; other elements—inorganic; elements of the body; basis of classification of foods; nutritive values influenced; names of classes of food-stuffs. 6, 7, 8. Proteids or nitrogenous foods—nitrogen as a gas and as a solid; importance as an element, effect of deprivation; from what obtained; chief nitrogenous substances—similarity in animal and vegetable; animal or vegetable food, which? 9. Fats or oils as food, importance of, when and where, chief office, composition of. 10. Non-nitrogenous food—nourishing properties, theories of modern chemists. 11. Amyloids or starches—comprise what, non-nitrogenous, other elements, quantity employed, prod-

ucts of what, in what found, contributive, importance, peculiarity of starch. 12. Water and other mineral foods—amount of water in body, office of, loss of and compensation for; water in solid food, quantity ordinarily needed, vast quantity taken accounted for, importance of purity. 13. Mineral salts—quantity in tissues, whence obtained, deficiency of—effects. 14. Common salt—importance of, flavoring, appetite and digestion affected; animals seek salt, effects of deprivation. 15, 16. Necessity for mixed diet—single articles incomplete in elements—examples; excess and deficiency in a single article—example of meat, bread; effects of deficiency or excess in elements; a varied diet; confinement to a single article—effects; effects of concentrated food; bulk required—reason; concentrated food combined with bulky; system misses any element; change of diet may benefit; longing—cause. 17. Quantity of different food-elements required daily—penalty of taking less; excess—results. 18. Conditions affecting increase or decrease.

CHAP. XVII.—1. Vegetable food-articles most common; important constituents—starch, fat, nitrogenous, etc. 2. Wheat—constituents, nutritious value. 3. Rye—compared with wheat, point of inferiority, where much used, “spurred rye” poisonous, whiskey from rye. 4. Oatmeal—richness, extent of use, desirability. 5. Cornmeal—extensively used, value, deficiencies, especial richness; hominy. 6. Rice—nativity, chief food of millions, nutritive value, deficiencies, use in warm climates, digestibility—value to the sick, large quantity for nutrition—reason, preparation. 7. Barley—constituents compared with wheat—value. 8. Pease and beans—similarity to cereals, more nitrogen—casein, digestibility when dry, etc.—disturbances, nutritive value, deficiency. 9. Potatoes—nutritive value compared, nativity, etc., solid components, deficiencies—how compensated, new and old, cooking—sweet potatoes. 10. (Table of Composition.) 11. Garden products—succulent vegetables, nutritive value, supply variety; salts; prevent scurvy. 12. Beets—richness, nutritive value. 13. Turnips, carrots, parsnips—chief constituent, other constituents—nutritive? 14. Cabbage and “greens”—nutriment small, value as food. 15–19. Tomatoes, asparagus, rhubarb, cauliflower, pumpkin, squash,—chief constituents and special value of each as food—deficiencies compensated in cooking. 20. Fruits—value chemically, beneficial, value in warm weather—cause, juice the most valuable—why; unripe, etc., and unwholesome. 21. Canned fruits—decomposition, poisoning by, character of cans. 22. Confectionery—nutritive value, pure, adulterated, kinds probably unwholesome; white candy.

CHAP. XVIII.—1. Animal food—quantity, variety; alimentary principles contained. 2. Animal bodies as food—chemical elements. 3. Meat—

constituents; flesh of what animals preferable. 4. Circumstances affecting value of animal food—age of animal, preparation for market, quick fattening, slop-fed. 5. Manner of slaughtering, removal of blood, the Jewish method. 6. Decomposition of meat, eaten soon when not frozen; tenderness of putrefaction—digestion related; breaking of fibres for tenderness—teeth in relation. 7. Value affected by cooking—influence of proper cooking. 8. Meats pronounced unfit for food—conditions. 9. Properties of meats—beef, nutritive value, varying flavor, in different animals, special parts, color when wholesome or unwholesome, wet, inelastic. 10. Veal—value, digestibility, when unfit—effects. 11. Mutton—digestibility, nutriment, in dyspepsia, dysentery; lamb—compared with mutton. 12. Pork—importance as food—reason; heat-producing; nitrogenous matter compared with beef; unclean food of hogs—effects; liability to disease—*trichinæ spiralis* and effects of, destruction of. 13. Salt meats, dried meats—nature and values. 14. Fowl or poultry—digestibility compared, nutritive value, white meat; broth, flavor, nature, value; flesh of carnivorous birds—nature. 15. Fish—constituents and food value; pink flesh, white flesh—values; decomposition, unwholesomeness; appearance of stale fish; odor as a test. Lobsters and crabs—constituents, digestibility, rapid decomposition—danger. Clams—tough, indigestible. Oysters—nutriment, digestibility, flavor. Fish as a “brain food”—confirmed? 16, 17, 18. Milk—constituent elements, importance as a food; a food for children, adults; varying composition—causes; improper feeding of cows—result; “barn-yard milk.” Adulteration of milk—methods, detection of; skimmed milk—innutritious—test. Care of milk—absorption of gases, germs, dust—prevention; metallic vessels—acid effects and poison generated; scalding of vessels. 19. Disease transmitted by milk—diseased cows, fermentation, infected by disease germs, epidemic disease from unwholesome milk—infection from water used. 20. Preventives against disease from milk. 21. Butter and cheese—nutritive values, digestibility, casein, rancid butter, adulteration of butter, absorption of impurities; cheese nitrogenous, etc., quantity eaten—limited; strong and indigestible. 23. Eggs—value as food, constituents, deficiencies; digestibility influenced by cooking; preservative methods. 24. Cooking—object of; results of poor cooking—unpalatable, innutritious, indigestible. 25. Cooking of meat—object to be attained, degree of heat at first—reason; broiling, roasting, baking—effectiveness, requisites; broiled meat digestible; boiling of meat—method, etc., making of soup—treatment of meat; frying as a method of cooking—objections, method, errors in process. 26. Cooking vegetables—philosophy of boiling; potatoes—boiling and baking of, nature of heat employed;

deficiencies in fats compensated. 27. Mixing of bread—fermentation, through kneading, limit of fermentation—reason, temperature of dough, and arrest of fermentation; unfermented bread, aerated bread. 28. Baking of bread—requisites of digestibility; underbaked, overbaked—effects; wrapping in wet cloths objectionable. Constituents of bread—deficiencies compensated. 29. Condiments—simple flavors few; lack of flavor in certain food articles; offices of condiments—classes; excessive use, injurious adulteration—examples.

CHAP. XIX.—I. Physiological offices of water—the instrument of change—solvent power; purity essential, appearances deceptive; pure water rare; pollution prevented. 2. Chief impurities—effects; varieties of water—hard, soft, etc.—causes. 3, 4. Rain-water—source, impurities—gases, soot, etc.; corrupting substances from exposed surfaces—putrefaction; contaminated by pipes, foul cisterns, etc.; clean cisterns—structure; properties of rain-water—when best of all. 5, 6. River, or surface water—source of supply, nature of impurities, character of strata, condition of surface of ground—effects; effects of sewage; few pure rivers in settled regions; purification of running streams; specific poisons carried; objection to river-water—pollution, examples (note). 6. Water of ponds, small streams, etc.—cause of impurities, diseases from; instance of typhoid fever epidemic. 7, 8, 9, 10. Spring water—nature, temperature, agreeable properties, essentials for purity, may be impure. Well water—shallow wells impure—cause; filth—sodden earth—percolation fails to remove impurity; influence of cess-pools, stables, etc. Filth-soaked ground in cities—wells polluted. Deep wells—nature of water, prevention of drainage from surface, disease and death from carelessness in drainage—duties. 11, 12. Hardness of water—nature, cause, effects on boilers, etc., cooking with. Evidence of injury to health; soft water better. 13. Water and lead-poisoning; coating of pipes by hard water; use of water from lead pipes—caution. 14–18. Means of purifying water—process of filtration, distillation, boiling, freezing, and efficacy of each; construction of simple filter—manipulation. 19. Detection of impure water—senses unreliable. 20. Temperature of water-supply, effects—example. 21. Cooling of water—process.

CHAP. XX.—I. General classes of drink; artificial drinks—inducement to use, liable to injure. 2, 3. Tea—constituents, nature, effects, varieties, use in China—reason; “tea tasters” and packers affected; value—dietetic and medicinal; stimulant—injurious to youth and nervous adults; in heart disease; to cause wakefulness—result. 4, 5. Coffee—constituent principles; exhilarating power, general effects. Tea and coffee—foods? lessening waste—consequence; relied on as food—result; Dr. Hayes’s statement.

6. Cocoa—source, constituents; stimulating and nutritive properties. 7, 8, 9. Adulterations of tea, coffee, and cocoa—methods, and extent. 10. Alcoholic beverages defined; alcohol—production, sources, materials. 12. Fermentation described. 13. Malting described—product. 14 Fermented liquors named, described, and quantity of alcohol stated. 15. Distilled liquors in common use named; source of; distillation described; distilled liquors—source of each, characteristics, coloring, etc., amount of alcohol contained. 16. Other constituents of alcoholic beverages—alcohol the active element; attractiveness, tonic properties compared. 17. Adulteration of alcoholic beverages—purity exceptional, adulteration alarming and shameful—evil consequences; substances employed. 18–20. Alcohol and its properties—color, odor, taste, volatile and inflammable, solvent powers, use in arts and sciences, etc.; affinity for water—antiseptic properties; allaying pain—deadening sensibility; physicians cautious in prescribing alcohol—reason. 21. Alcohol as a beverage and as a poison—nature of a true beverage; affinity for and extraction of water—thirst created; action of alcohol when dilute and when strong—blistering, disorganizing tissues, thirst-creating. 22. Alcohol and albuminous elements of food—arresting digestion. 23. Alcohol's general effects on nerve-centres, intestines, digestion, blood—final results of dram-drinking. 24. Considerable quantity taken during or after eating—effects on digestion; results of continuance; taken before labor of the day—harm. 25. Misery inflicted.

CHAP. XXI.—1. Digestion defined; when perfect—importance. 2. Ill-temper, etc., arising from indigestion; violation of simple laws—results. 3. Organs named—appendages. 4. Alimentary canal described—membrane, secretions, juices, coats, etc. 5. Peritoneum described—mesentery. 6. Processes named in order. 7. Mutual dependence of processes. 8–12. Mastication—organs, importance, process—movements; forms of teeth—purpose; mastication and the will, preventing disorders, manner of eating; comments of the Lancet on mastication; toothless stomach. 13. Insalivation—importance, moistening not the sole purpose, chemical action, definition. 14–18. Salivary glands, location, number, structure, each named and described (size, ducts, location); functions, saliva; exciting the glands to action—solid food and mastication. 19, 20. Nature and action of saliva—color, etc., alkaline nature, daily amount; action or use—mechanical, chemical; action on starch—importance hence; other liquids not effective substitutes; saliva—proteids and fats. 21. Effects of tobacco on salivary digestion—dryness, thirst, waste, depraved secretion—sewers. 22. Acids and salivary digestion—delay, influence in health and disease, reducing corpulence. 23–25. Deglutition—definition, process—pharynx, soft palate, œsophagus,

constrictors; closure of wind-pipe in swallowing — rapidity important; œsophagus — structure, action of muscles.

CHAP. XXII. — 1-5. Chymification — form and location of stomach, capacity; orifices, valves and their functions, curvatures; coats — mucous, muscular, peritoneal — rugæ, gastric glands and tubes and their offices, muscular structure and movements, attachment and support. 6-8. Gastric juice — changes caused by, acid nature, elements — pepsin, etc., importance of; action of gastric juice on proteids — peptones, on fat, starch, and sugar; quantity of gastric juice — while fasting, when aliment is taken. 9. Stomach digestion — a closed chamber, contractions and movements of food; arrangement of food in stomach, change in mucous lining and flow of juice, movements and changes observed by Dr. Beaumont, resolution into chyme, accumulation, action of pylorus; temperature of stomach — influence of cold liquids on digestion. 14. Absorption from the stomach — peptone, saccharine fluid, conveyance by portal vein to liver, etc. 15, 16. Time required for stomach digestion — varying with food, bulk, health — maximum; relation of rapid digestion to nutrition, delayed digestion. 17, 18. Effects of alcohol on the stomach — irritation, affinity for water — parching, destroying glands, tongue's lining, paralyzing nerves and vigor, etc.; observations of Dr. Beaumont in case of St. Martin, and of Dr. Day relative to inflammation, thickening of membrane, congestion, interruption of movement of food, etc. 19-21. Alcohol and digestion — flow of gastric juice should be natural — extortion, exhaustion, impaired digestion; absorbs water — pepsin affected, juice unfitted, alcohol unchanged enters blood; albuminoid food toughened, retarded change, undigested food, train of diseases. 22. Alcohol and thirst — absorption of water from tissues, and thirst, thirst-quenching alcoholic beverages — water superior. 23-25. Alcohol and accumulation of fat — waste and repair should be uniform, effects of disturbance, cause of corpulence, deficient change and excretion — fat; accumulation of alcoholized particles — fat, true nutrition, excessive fat a disease — fatty degeneration; beer-drinkers' fat, no strength added, disease induced — instances, complications in case of injury — surgical operations rendered dangerous. 26-28. Effects of tobacco on digestion — salivary glands overtaxed, etc., waste and salivary digestion, nicotine absorbed — effect; swallowing tobacco juice — effect; *nicotia* a deadly poison; depraved appetite — will enslaved, effect on blood, brain, nerves — nervousness, languor, disturbed sleep, etc.

CHAP. XXIII. — 1, 2. Chylification — difficulty of investigation, knowledge obtained by experiment on lower animals. 3. The intestines described — coats, attachment to spine — mesentery, the small and the large intestine — valve connecting and its function. 4-7. Divisions of small intestine —

names, location, form, direction, total length. 8-10. Large intestine — divisions, location, form, peculiarities; cæcum — vermiform appendix — use, danger; divisions of the colon; the rectum; total length. 11, 12. Interior of intestines — mucous coat, folds and motion — office, blood-vessels, absorbents — covering; villi — number and function. 13. Lacteals — location, shape, structure, appearance, office; ramification of trunks; receptacle of chyle, thoracic duct, chyle conducted to subclavian vein enters heart. 14. Intestinal glands — secretion and nature of; bile, pancreatic juice — sources. 15, 16. The liver — size, secretion, gall-bladder; functions of liver — doubt; office of bile — result of experiments on an animal, etc.; liver secretes sugar. 17. Pancreas — location, pancreatic juice — office. 18. Spleen — location, functions unknown, effects of removal from animals; plausible theory of office. 19. Kidneys — number, form, dimensions, location; structure; functions; constituents of secretion; ureters — size and function; effects of suppression. 20-22. Chylification — function of small intestine — digestion; secretion throughout length; digestion in duodenum — entry of juices, and their action; probable action of bile — alkaline; action of pancreatic juice; action of the intestinal juices; quantity poured out and re-absorbed; food in solution — absorption; nature of juices combined — alkaline; result of action — chyle. 23, 24. Absorption of chyle — action of intestine, of the villi, conduction to heart, entering venous blood, pumped to lungs — arterialized blood. 25. Evils of indigestion — insoluble elements, effete matters secreted and expelled — function of intestine; undue retention of effete products — effects.

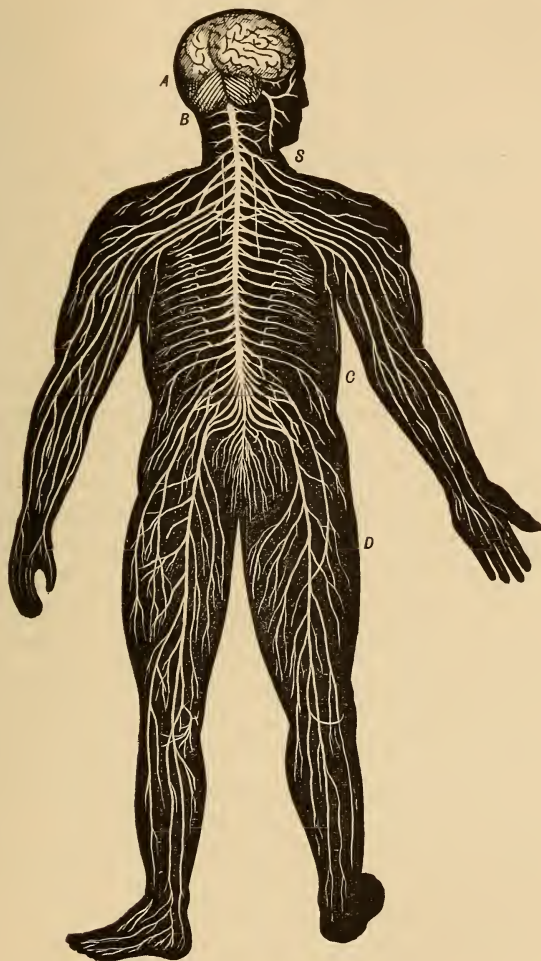


Fig. 44. The Cerebro-spinal System.

A, cerebrum ; B, cerebellum ; S, spinal cord ; C, cauda equina ; D, great sciatic nerve.

THE NERVOUS SYSTEM.

CHAPTER XXIV.

THE NERVOUS SYSTEM. — THE BRAIN.

1. **Functions of the Nervous System.** — Every movement of the body, whether voluntary or involuntary, is caused and governed by some portion of the nervous system. If we *will* to do anything, we do it through the agency of nervous matter which acts as a medium between the mind and the muscles. Nerve-matter does not produce motion by its own contraction, but by its mysterious influence over the muscles in which its fibres terminate. Not only every motion, but also every sensation, is dependent upon it. The material of which the nervous system is composed constitutes the highest order of organized matter, and in some mysterious way possesses the hidden force or power which constitutes what is called *life*.

2. **Divisions of the Nervous System.** — The nervous system consists of two connected parts, called the *cerebro-spinal system* and the *sympathetic system*.

3. The *cerebro-spinal system* consists of the *brain*, the *spinal cord*, and all the *nerves* given off from the brain and the cord. The nerves of this system are distributed chiefly to the voluntary muscles, the skin, and to the

other organs of the senses,—the eye, ear, nose, and tongue.

4. The *sympathetic system* consists of a number of *ganglia* (knots) of nerve-matter, connected by intervening nerve cords, which are situated on each side of the vertebral column, and extend from the base of the skull to the end of the column. The nerves of this system pass off in various directions to internal organs of the body,—the stomach, heart, blood-vessels, etc.,—control involuntary movements, and regulate the supply of blood to the various parts. Some of the nerve branches form communication with the cerebro-spinal system.

5. **Nervous Tissue.**—Examination of the substance of which the nervous system is composed reveals two kinds of matter, which, on account of their color, are called the *gray matter* and the *white matter*.

6. The *gray matter* presides over all mental action and sensation, while the *white matter* imparts motion to the muscular tissues to which it is supplied.

7. There is a fundamental difference in structure between the gray and the white matter. The white matter consists entirely of *nerve-fibres* supported in a delicate framework of connective tissue and accompanied by blood-vessels. The *gray matter* contains in addition a number of *nerve-cells*, some of which are of considerable size. These cells are entirely absent in the white matter. The gray matter is pulpy and softer than the white, and the white greatly exceeds the gray in total amount.

8. **The Brain.**—The *brain*, the great nerve-centre of the body, is the large, upper portion of the cerebro-spinal system filling the cavity of the skull. It consists chiefly of

soft nerve-substance, the gray matter situated on the external surface and the white matter located internally. It is the seat not only of the nervous force which regulates the whole body, but is also the throne of the intellect and the home of the emotions.

9. The average weight of the human brain in the adult male is about 48 ounces, and in the female 44 ounces. The maximum weight in the male, in a large number of cases, has been found to be 65 ounces, and the minimum 34 ounces; the maximum in the female 56 ounces, and the minimum 31 ounces. The human brain is larger than that of any of the lower animals except the elephant and the whale, the brain of the former weighing from eight to ten pounds, that of the latter somewhat more than five pounds. While the brains of these animals are larger than the human brain, they are not so finely organized; and to this latter fact the human brain owes its superior intellectual power. Indeed, the varying mental capacity of different individuals is due to the texture or organization of the brain rather than to its volume or weight, within certain limits. It does not necessarily follow that, because an individual is physically a giant and has a brain proportionately large, he is therefore intellectually a giant.

10. To protect the brain substance from pressure and injury, three membranes are interposed between it and the inner surface of the skull. First, the surface of the brain is covered with a very thin and delicate membrane called the *pia mater* (Lat., pious mother), which consists of a thickly meshed network of small arteries and veins supported by connective tissue. From this membrane the brain receives its supply of blood. Second, a delicate and transparent membrane called the *arachnoid* membrane (Gr.

arachne, a spider's web ; and *eidōs*, form), consisting of two layers, one of which covers the *pia mater*, and the other reflected over the under surface of the next upper membrane. In this way it forms a closed sac which contains a certain amount of liquid and acts as a cushion. Finally, over this is the third membrane, the *dura mater* (Lat., hard mother), which is tough and fibrous. Its outer surface is rough, and is in contact with the inner surface of the skull ; its inner surface is smooth and in contact with the *arachnoid* below it. The surface of the brain is marked by a deep fissure passing from before backward, and thus divided into two lateral masses called the *right* and the *left hemispheres*.

11. The brain consists of several parts, the chief of which are the *cerebrum* or *greater brain*, the *cerebellum* or *lesser brain*, the *pons Varolli* (Lat., *pons*, a bridge), and the *medulla oblongata* (Lat., oblong marrow). A description of the structure and functions of each of these divisions follows :—

12. **The Cerebrum.** — The *cerebrum* occupies all the upper and frontal portion of the cavity of the skull, and comprises about nine-tenths of the weight of the entire brain. It consists of two hemispheres, the *right* and the *left*, and is composed of a thick layer of *gray* matter surrounding *white*, fibrous nerve-substance. The surface of the brain (the *gray* matter) is drawn up into numerous irregular folds or *convolutions*, by which its area is greatly increased. Beneath the layer of *gray* matter are found interlacing, white fibres, so intimately combined that the anatomist's knife is unable to separate them completely. In parts of the *cerebrum* these fibres cross and recross, and thus the parts of the brain are connected. It is from

the crossing of these fibres in the centre of the brain that injuries upon its left side are manifested by paralysis on the right side of the body, and *vice-versa*. Wherever may be the exact seat of the motor principle, the brain exercises a cross-action on the muscles; that is, the left hemisphere induces the movements of the right side of the body, and the right hemisphere those of the left. The white fibres

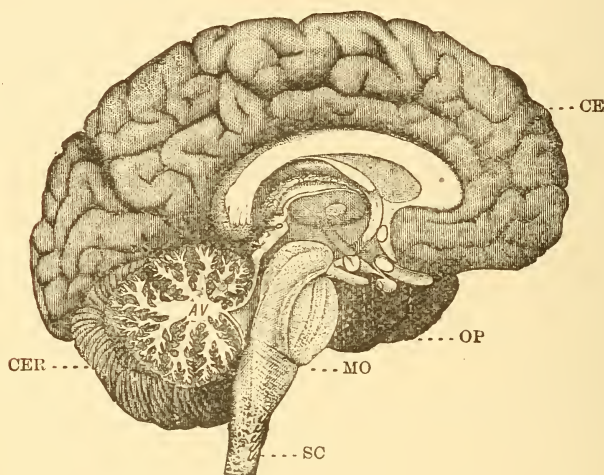


Fig. 45.

EXPLANATION.

This figure represents the left half of the brain. CE, the *cerebrum*; CER, the *cerebellum*; MO, the *medulla oblongata*; OP, *optic nerve*; SC, *spinal cord*; AV, *arbor vitae*.

of the brain also pass down to the spinal cord and conduct the *impulses of motion*. Other fibres coming up from the cord convey *sensory impulses* to the gray matter. Thus there is seen to be a circuit as in a telegraphic system—messages being sent from and other messages being sent to headquarters.

13. The cerebrum is the principal seat of intelligence, the will, the emotions, sensation, and voluntary motion. It would be beyond the scope of this volume to enter into a detail of the functions ascribed to the various parts of the *cerebrum*; but brief mention of the matter will open the way to future research, if that is desired.

14. Ferrier has mapped out areas on the brain, each of which, as proven by experiment upon animals, is the seat of distinctive nerve-impulses.¹ Examination of the brains of various animals appears to have demonstrated that the size of the brain and *particularly the complexity of the convolutions* are proportional to the intelligence of the animal. Thus, in the rabbit the cerebrum is small in proportion to the brain as a whole, and its surface is smooth. In the monkey the cerebrum is proportionately larger, and its surface is considerably convoluted. In man the cerebrum is still larger and more convoluted.

15. Knowledge of the functions of the cerebrum has been partly derived from cases of injury or disease of that organ and partly by means of experiments made on the lower animals. Thus, when the cerebrum is diseased or injured, the power of manifesting mental faculty is more or less lost. Will, reason, and memory, one or all, become impaired. When the cerebrum of an animal is removed, all power of voluntary movement is lost, and the animal remains in a state of stupor, retaining, however, the power of involuntary or undesigned movement.

16. The functions of most parts of the brain which lie in front of the *medulla oblongata* are very poorly under-

¹ These areas are called *motor centres* by some authorities, but exception is taken to this term from the fact that the same results may be obtained when the cerebrum is removed; and hence, though the surface shows evidence of being concerned in these distinctive functions, other parts are associated with it.

stood. "Observation has enabled physiologists to distinguish in the spinal cord and the nerves the portions that preside over sensation or over motion; and the results of experiments upon the lower animals make it evident that certain regions of the cerebrum are endowed with sensibility, while others are insensible; but we have not yet been able to recognize in the brain-mass the central organs which preside over sensation and over motion."

17. . . . "The brain may be wounded, and even a portion of it may be destroyed, without any sensible change in the intellectual faculties. . . . And, indeed, in the insane, science can in many cases prove nothing but their misfortune, of which no part of the brain suggests, in the slightest degree, the cause." Physiology, therefore, is very reserved in regard to the functions of the cerebrum, and most of the theories concerning them are disputed and uncertain.

18. **The Cerebellum.** — The *cerebellum*, or *lesser brain*, is situated in the lower and back part of the skull, underneath the back portion of the cerebrum, with which it is connected. It differs materially from the cerebrum in structure and in function. It consists of two hemispheres, each composed of an external layer of gray matter surrounding and dipping down deeply into the white, fibrous matter. The surface of the cerebellum is also convoluted, but in a different manner. The gray and the white matter are so interlaced, that, when cut across transversely, they present the appearance of a branching tree; and hence the name *arbor vitæ* (tree of life) as applied to this section of the cerebellum.

19. Only one of the various functions which physiologists have attributed to the cerebellum has been generally

admitted in later times. Its chief office appears to be the *regulation* or *co-ordination of muscular movement*. When an animal has had its cerebellum removed, it can move any voluntary muscle at will; but a confusion in the



Fig. 46. The Under Surface of the Brain, showing the Origins of the Twelve Pairs of Nerves.

EXPLANATION.

A, cerebrum; B, cerebellum; C, medulla oblongata; D, pons Varolii. The Roman numerals distinguish certain of the cranial nerves.

movement is caused, similar to that induced by intoxication, the muscles acting irregularly. Thus, voluntary movements do not originate in the cerebellum, but only the power to produce harmonious action of parts of the body. An animal retains sensation when its cerebellum

has been destroyed, and both hemispheres may be sliced away without causing the slightest pain.

20. The Pons Varolli.—The *pons Varolli* (so called from the anatomist Varolius, who first described it as a bridge) consists of several layers of fibres which pass down from the *cerebellum* and meet in the middle of the base of the brain. It forms a bridge or bond of union between the cerebrum and cerebellum above, and the *medulla oblongata* below.

21. The movements of locomotion are believed to originate specially in the pons Varolli, and it has a cross-action on the muscles. It is a centre of perception for sensations of touch, but it is improbable that it can appreciate sensation without the aid of the cerebrum.

22. The Medulla Oblongata.—The *medulla oblongata* (Lat., oblong marrow) is the name applied to the enlargement or bulb of the upper extremity of the spinal cord. It is situated within the skull and is continuous with the brain, being about an inch in length. Its gray matter occupies the interior.

23. The medulla oblongata acts as an important centre for the nerves which regulate the blood-vessels (vasomotor nerves) and the circulation of the blood. It also governs those involuntary movements which constitute the acts of breathing, swallowing, the secretion of saliva, and many others. “When, therefore, it is remembered that every impulse passing between the higher parts of the brain and every nerve of the body (excepting those of sight and smell) must make its way through some portion of the medulla oblongata, its importance becomes obvious.” We see that the vital functions are intimately connected with it. When it is injured or destroyed, breathing ceases,

all vital action is suspended, and instant death is the result. It also possesses properties similar to those of the spinal cord, which will be treated of in the following chapter.

CHAPTER XXV.

THE SPINAL CORD. — THE NERVES.

1. **The Spinal Cord.** — The *spinal cord* is a cylinder of nerve matter, continuous with the brain, contained in the long cavity of the back-bone. It extends from the medulla oblongata downward to about the second vertebra of the loins, and is from eighteen to twenty inches in length, being nearly as thick as the little finger, and weighing about an ounce and a half. It is covered by three membranes prolonged from the brain. The second, or arachnoid membrane of the cord, unlike that of the brain, is not in contact with the *pia mater* beneath it, but forms a loose sac around it. The *dura mater*, or outer membrane, also does not lie close against the inner surface of the bones of the cavity, but is separated from it by a layer of fatty tissue which forms a soft, protecting sheath, enabling the column to bend without injury to the cord.¹ Like the brain, the cord is divided into right and left halves by two deep fissures, one in front and the other at the back of the cord, penetrating almost to the

¹ An uninjured piece of the *cord* may be readily procured from a "loin" of mutton or from a "sirloin" of beef. Its general appearance may then be noticed while it is still fresh, after which it may be soaked in alcohol till sufficiently hard to be cut into sections and the arrangement of its matter noticed.

centre. These halves are united by a band of gray matter. In the centre of the cord is a very small canal which can be seen only with the aid of a microscope. The gray nerve-matter of the spinal cord is in the interior, and is surrounded by the white matter which forms the surface.

2. Large nerves are given off right and left from the spinal cord throughout its length. It is not of equal diameter throughout, but has an enlargement in the region of the neck and another in the region of the loins. These enlargements correspond respectively to the places from which the nerves of the upper extremities, and those of the lower extremities, originate and pass out through openings in the bones.

3. The spinal cord gives off both *motor* and *sensory* nerves, and is therefore both a centre of motion and sensation. It imparts to the nerves of the trunk and limbs the power of voluntary motion. To the heart, the blood-vessels, the organs of breathing, etc., it imparts nervous force required to sustain their involuntary movements. It will thus be seen that the functions of the cord are, in part, similar to those of the *medulla oblongata*, the latter transmitting impressions from the cord to the brain, and the impulses of the will from the brain to the cord.

4. **Reflex Action.**—When the cord is severed (in the middle of the back, for instance), the legs and all other portions of the body below the point of division become insensible, and no effort of the will can make them move; all parts above the section, however, retain their sensibility and powers of motion. In accidents the cord is frequently so much injured as to be cut in two in effect, and paralysis of the lower part of the body results. Pinching,

or otherwise irritating the limbs which are thus disconnected from the brain, causes violent movements of all the muscles supplied by nerves given off below the cut, and the limbs draw up suddenly by the contraction of their muscles ; but this occurs without sensation being felt by the brain, and without exercise of the will. Such phenomenon is named a *reflex action*. It consists of an irritation or disturbance of sensory fibres which is conducted by a *sensory* nerve to a nerve-centre, and a reflection of this irritation from the nerve-centre through one or more *motor* nerves causes a contraction of the muscles in which these nerves terminate.

5. The spinal cord is, therefore, not merely a conductor of impressions, but it is also a centre for reflex actions. This peculiar power is possessed by the gray matter of the cord only, the white substance being the conductor of impulses.

6. Numerous reflex actions are occurring continually in the body without being recognized by the brain, among which are included the actions of organs necessary to life. Thus, the action of the muscles employed in breathing is the result of reflex action, for in this case the imperfectly ærated condition of the blood sent to the lungs produces its special irritation of certain *sensory* nerves ; and the impression thus made is conveyed by them to a nerve-centre (the *medulla oblongata*), and from it reflected through *motor* nerves which move the muscles of the ribs, the diaphragm, etc., concerned in breathing.

7. Again, if the substance of the spinal cord is cut through on one side only, sensation is destroyed in parts below the division *on the opposite side of the body*, while the power of voluntary movement is lost *on the same side*.

Hence, the *sensory fibres* must cross over immediately on entering the cord, while the motor fibres pass down on the same side on which they leave the cord. Further, if the cord is severed lengthwise into halves, all sensation is destroyed, while the power of voluntary movement remains unaffected. But physiological knowledge of the way in which impulses pass up and down the cord is limited, and hence very satisfactory statements cannot be made regarding them.

8. The Nerves in General. — The nerve-trunks differ materially from the substance of the brain and spinal cord. Instead of being soft and pulpy, they are composed of tough, thread-like filaments. A number of these filaments are bound together in a delicate sheath of connective tissue; a number of these small bundles are again enclosed in another sheath, and these larger ones again unite and are surrounded by an outer sheath to form the large trunks. When a large trunk divides, the smaller bundles are separated from each other and pass off to form nerve-branches.

9. Sensory and Motor Nerves. — Nerve *filaments* or *fibres* that conduct impressions of pain, touch, or any other sensation to nerve-centres are called *sensory* or *afferent* filaments. Those which convey impulses from nerve-centres to produce movements of muscles are termed *motory* or *efferent* filaments.¹ Most of the nerves of the body, especially those given off from the spinal cord, consist of both sensory and motory fibres, and hence conduct impulses in both directions, but not by the same fibres ;

¹ The terms *afferent* (Lat. *ad*, to ; and *fero*, I carry) and *efferent* (Lat. *e*, out ; and *fero*) are probably preferable to *sensory* and *motory*, because the irritation of the former does not always produce sensation, and the irritation of the latter is not always followed by motion.

these are called *mixed nerves*. Some nerves, as those which enable us to see, hear, and smell, consist entirely of sensory fibres.

10. Nerves have no power to generate impulses, but can conduct those already produced along their fibres either to or from a nerve-centre. Nerve-centres, on the contrary, have the power to produce and to conduct impulses; and they act as receivers and transmitters, as well as generators, of impulses.

11. The nerves are divided into two sets, the *cranial* and the *spinal*; the former arising from the brain and passing through small openings in the base of the skull, while the latter arise from the spinal cord and pass through openings in the sides of the bones of the spine. Nerves are given off in pairs, the nerves of each pair extending in opposite directions.

12. **The Cranial Nerves.**—Twelve pairs of nerves, succeeding one another from before backwards, are given off from the brain. Nearly all of these nerves are either directly or indirectly traceable to the medulla oblongata, the only exceptions being the nerves of sight and of smell. “As might be expected from this circumstance alone, the medulla oblongata is an extremely important part of the cerebro-spinal axis, injury to it giving rise to immediate evil consequences of the most serious kind.”

13. The cranial nerves include nerves of the special senses, nerves of common sensation, nerves of motion, and mixed nerves. The nerves of special sense include those that go to the eyes, ears, nose, tongue, and throat, and respectively conduct the sensations of sight, hearing, smell, and taste. The other cranial nerves conduct sensory and motory impulses to the muscles of the eyes, face,

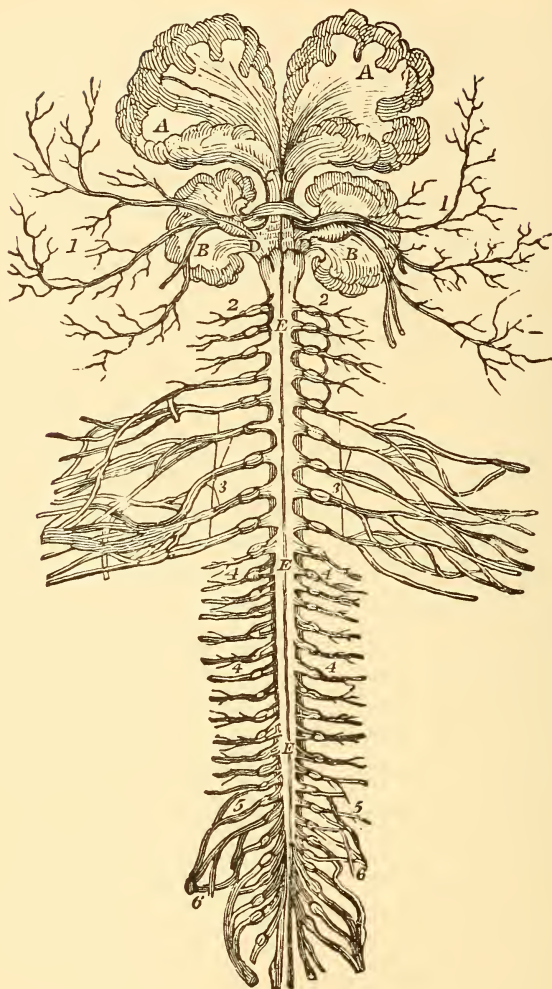


Fig. 47.

EXPLANATION.

A, A, the cerebrum; *B, B*, the cerebellum; *C, C*, the union of the fibres of the cerebrum; *D, D*, the union of the fibres of the two sides of the cerebellum; *E, E, E*, the spinal cord; *1, 1*, the cranial nerves; *2, 2*, the branches of the spinal nerves that extend to the neck and organs of the chest; *3, 3*, the branches of the spinal nerves that extend to the arms and fingers; *4, 4, 4, 4*, the dorsal nerves that extend to the walls of the chest, back, loins, and abdomen; *5, 5*, the lumbar nerves that also extend to the chest and abdomen; *6, 6*, the sacral nerves that unite and form the great sciatic nerve of the legs.

mouth, throat, stomach, lungs, heart, and other internal organs. One pair of the cranial nerves, the *pneumo-gastric* (Gr. *pneuma*, breath; and *gaster*, stomach), a very important mixed nerve, sends both sensory and motory fibres to the larynx, lungs, œsophagus, stomach, heart,

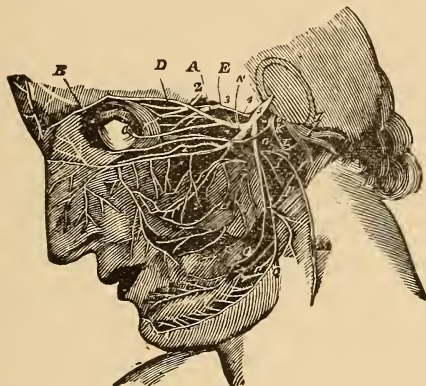


Fig. 48.

EXPLANATION.

2. the *optic nerve*, nerve of sight connected with the eyeballs.
- 3, the *motor oculi*, used to move the eyes.
- 4, the *trochlearis*, which rolls the eye downward.
5. the *tri-gemini*, whose three branches extend to the upper part of the face, to the upper jaw and teeth, to the lower jaw and teeth (this nerve is affected in toothache), to the tear-gland of the eye, and to the nose.
- O*, the nerve of the tongue and of taste.
- P*, a branch of the nerve of taste, going to the ear.
- Q*, the nerve of the teeth of the under jaw, which finally comes out on the chin to supply the muscles of expression.
- 7, the *auditory nerve*, being the nerve of hearing.

and liver. It will thus be seen that any disturbance of its branches may cause serious complications of several important organs. Each pair of nerves has a name indicative either of its function, location, or form.

14. The Spinal Nerves. — The large nerves that originate from the spinal cord and pass off right and left are termed *spinal nerves*. There are thirty-one pairs of these nerves, divided into groups according to the regions of the spinal cord from which they spring.¹ At the lower end of the cord the nerves pass out in the form of a bundle which is called the *cauda equina* (Lat. horse-tail) from its fancied resemblance to the tail of a horse.

15. The nerves in the region of the neck distribute themselves to the surface and to the deeper portions of the neck, to the outside of the head, to the upper portion of the back, to the shoulders, and to the arms; those of the region of the back and of the loins are distributed to the muscles of the back and loins, to the walls of the chest and abdomen, and to the surface of the legs; the remaining pairs from the lower portion of the cord are distributed to the pelvis and to the legs. Several of the latter pairs unite and eventually terminate in great trunks called the *sciatic* nerves,² the largest in the body, which extend to the muscles of the back of the thighs, and thence by two smaller trunks to the muscles of the legs and feet.

16. Each spinal nerve arises from two roots, one consisting of white matter and constituting the *motory* root, and the other of gray matter and forming the *sensory* root. On passing from the cord, these roots become united to form a spinal nerve-trunk consisting of sensory and motory fibres placed side by side. It follows, therefore, that

¹ There are eight pairs of nerves in the region of the neck, called *cervical* nerves; twelve pairs in the region of the back, called *dorsal* nerves; five pairs in the loins, called *lumbar* nerves; five pairs in the region of the sacrum, called *sacral* nerves; and one pair at the end of the spine, called *coccygeal* nerves.

² In the distressing disease known as *sciatica*, these nerves are affected.

these nerves are *mixed*. After division and sub-division, they supply fibres to the skin and to the voluntary muscles generally. In other words, these nerves, by their complex ramifications, supply all portions of the body not supplied by the cranial nerves. Their divisions are so minute and so closely distributed as to make it impossible to place the point of a needle on any portion of the body without touching a nerve-fibre.

17. Sensation may be destroyed in any portion of the body while that portion still possesses the power of motion; and on the contrary, a portion of the body, a limb for example, may be deprived of the power of motion and yet retain its sensitiveness to touch, pain, etc. These facts early revealed the existence of two orders of nerve-fibres, one sensitive and the other motor. Later, and by actual experiment, it was demonstrated that their roots sprang from distinct portions of the spinal cord.

18. Experiments made upon living animals have shown, (1) that when the *trunk* of a spinal nerve is irritated, as by pinching, applying a hot iron, etc., all the muscles to which the nerve is distributed contract, and that pain is felt; (2) that when only the *anterior root* of the nerve is irritated in the same way, the muscles contract, but no pain is felt; (3) that when the *posterior root* alone is irritated, there is no contraction of the muscles, but pain is evidently felt. Hence it is clear that the power of producing muscular motion is lodged in the fibres of the anterior roots of the nerves, and that the power of conducting sensation resides in those of the posterior roots, the former being *motory* and the latter *sensory*.

19. In all the experiments mentioned, there is evidence that when a nerve is irritated, a something, probably a

change in the arrangement of its molecules, is propagated along its fibres. If a motor or a sensory nerve be irritated at any point, contraction in a muscle or sensation in the nerve-centres immediately follows. But if the nerve be cut, or even tightly tied at any point between the part irritated and the muscle or the central organ, the effect ceases at once, just as cutting a telegraph wire stops the transmission of the electric current or impulse.¹ When a limb "goes to sleep," it is commonly because it has been subjected to pressure sufficient to impede the circulation of the blood, and to obstruct the nervous current in the nerves supplied to it.

20. The incalculable utility and importance to us of having these nerves perform a double function is another proof of the surpassing Providence which planned the animal structure. The facility and promptness with which we are enabled to know that our muscles are contracting when we wish it, and to estimate exactly the amount and direction of the contractions by the aid of the so-called *muscular sense*, allows us to prosecute our daily occupation without abstracting the attention of any of the other senses from their special operations. This "muscular sense" has been recognized by some authorities as a sixth special sense.

21. **The Sympathetic Nervous System.** — On each side of the spinal column in the upper part of the abdominal cavity

¹ It is an interesting fact that when irritation is applied to that portion of a cut spinal nerve which remains in communication with the brain, the pain is not felt at the point of irritation, but is always referred to the part in which the nerve naturally terminates. The man who has lost an arm or a leg feels pains which he does not refer to the stump which remains, but to the hand or foot which he has lost. The irritation is transmitted directly to the brain by one or more sensory nerves primarily destined to these parts, and the brain simply refers the sensation to the extremities of the nerve irritated, as though they were still in communication.

is a large *ganglion* or collection of nerve-matter connected with the brain by a beaded cord. These beads are smaller *ganglia* which act as reservoirs for nerve-force. Nerves are distributed from these centres to the heart, lungs, stomach, liver, etc. Branches run along the blood-vessels also, and from the diverging courses of all the branches the name of *solar plexus* has been given to the central ganglia.

22. In so complex an organization as man, it is very difficult, often impossible, to state the points of difference in the actions of various parts, and this is especially the case in this part of the nervous system. The *sympathetic system* is so called because it is supposed that it establishes a sympathy between the various organs of the body. Though the functions of the *general* nervous system and the sympathetic are so different, their anatomical union and the interlacement of their fibres cause them to react upon each other; but their relations are not thoroughly understood.

23. In all cases of severe shock, the ganglia of the sympathetic system are largely involved. When any single organ is diseased or injured, the irritation of the branches of the nerves supplied to it causes a sympathetic action in other organs; and it thus often happens that some unfavorable symptom of one organ is due to a diseased condition of one remote from it.

24. There must be perfect harmony between the two nervous systems to maintain health. If the cerebro-spinal system is too active, some nerve-force is taken away from the sympathetic system, and failure in vital processes may result. Again, when the sympathetic system acts too vigorously, nutrition is too active, the grosser

part of the living organization predominates, and mental activity is held in abeyance.

25. The sympathetic system is beyond the control of the will, and presides over the involuntary movements in the processes of nutrition, the circulation, secretion, excretion, etc.

26. **Nervous Impulses.** — A nervous impulse may be generated as follows: An impression made on the skin (as for instance by the prick of a needle) causes, by a tearing of the substance of a nerve-cell, certain changes in that cell, and produces what physiologists now call an *explosion of nerve-force*. This explosion causes a movement along the nerve fibres which is continued until it reaches a collection of nervous matter, principally composed of cells, called a *ganglion*; here an increased explosion is produced, and, at the estimated rate of thirty feet per second, the movement is carried on to the brain, which recognizes the impression.

27. How does the brain know it is a needle that is pricking? Only by having been educated to that knowledge. The infant does not know what hurts it, and it is only by repeated impressions that knowledge is obtained. The mind, after a time, realizes cause and effect. But prior to this education, nature instinctively prompts a removal of the cause of pain, and the will sends out along the motory nerve fibres that return to the part the mandate to remove the offending body. Thus before the fullest development of the faculties, an instinctive means of protection for organized beings has been provided.

28. **The Mind.** — In reply to the inquiry, "What is *mind*?" some one has answered, "No matter;" and to that of "What is matter?" has replied, "Never *mind*."

It is neither desirable nor practicable to enter deeply the realms of psychology in this treatise upon the human body.

29. The mind, intellect, or thought is the crowning function of the cerebrum, and consists of a number of faculties, such as memory, reason, judgment, imagination, conception, etc. Just how thought is produced cannot be explained. It has been claimed that all mental efforts result from a series of explosions that take place in the ultimate nerve-cells of the brain. However this may be, it is certain that there is as much loss of tissue after mental as after muscular effort ; and it is easily demonstrated that the material eliminated from the body after continued labor of the mind is the product of combustion of nervous substance.

CHAPTER XXVI.

THE ESSENTIALS OF HEALTHY NERVOUS ACTION.

1. **Primary Requisites.** — The healthy action of the nervous system depends chiefly upon the normal condition of other portions of the body and the proper performance of functions by its various organs.

2. It is necessary that the food shall be of a kind that can be converted into rich blood. The blood should be regularly and equally distributed ; there should be no artificial impediment to its circulation. The functions of the skin, lungs, kidneys, and bowels should be properly performed in order that the waste products may be elimi-

nated from the body. A normal amount of bodily heat should be maintained. The nerves, especially the large nerves of the limbs, should be free from pressure, and should be able to convey and receive impressions without unnatural stimulation.

3. Diseased and disordered functions of an organ produce an irritation of the nerve-fibres distributed to it, and, by sympathetic action, other nerves participate in the irritation, the nervous system becoming more or less involved in the disturbance. Hence, it is primarily necessary to maintain the normal condition of the various organs and their functions; for when these, or any of them, are affected, they must be restored to healthy condition and normal functions, in order to maintain or to restore healthy nervous action.

4. Again, properly regulated *work*, *recreation*, and *rest* must be taken into chief consideration in endeavoring to maintain nervous vigor.

5. **Mental Work.**—The brain and nervous system may suffer not alone from over-work. It may be the victim of insufficient work. Like the muscles which atrophy or waste from disuse, the brain may become weak from want of employment and mental food.

6. Active mental labor, varied by proper muscular exercise, keeps up a nervous activity that is constantly imparting renewed vitality to every organ and part of the body, and thus tends to prolong life. In a word, it may be stated that the most intelligent, and those devoted to well-regulated brain-work, live longer, as a rule, than those who perform severe physical labor without proper rest and recreation.

7. *Regularity* tells with marked effect on the physical

and mental health in all questions of work, exercise, recreation, meals, sleep, and rest. *Work* demands, as a primary condition for its perfect performance, regularity of its periods. Beyond a certain point, no amount of will-power can enable us to continue either mental or physical effort. "The experience of every-day life goes against giving credit to 'spurts' of work, and the fable of the hare and the tortoise includes a physiological as well as a moral application. As a matter of fact, the trades and professions in which break-down from overstrain most frequently occurs, are not those requiring hard, regular application, but those entailing *severe temporary strains*. A laborious occupation may be healthful enough, provided the work is performed with regularity. Contrariwise, an easy occupation, indulged in under conditions of strain, may become thoroughly prejudicial to the health of the worker." This can readily be accepted in regard to either mental or physical labor, without need of details.

8. Rest and Sleep. — All severe or protracted mental or physical labor is followed by a feeling of weariness or exhaustion. This indicates that too great demands have been made on the tissues, and that the waste resulting from continued activity is becoming greater than the supply of nervous force. Work continued under such conditions does not produce satisfactory results; and when too severe and protracted may terminate in nervous exhaustion. This fact is sufficient to indicate the importance of rest at the proper time, in order that the overtaxed brain-cells and other parts of the nervous system may have opportunity to recuperate. It may be that a short period of rest, or the turning of the attention to some other mental employment, may provide sufficient

relaxation ; or there may be required that complete repose that can be obtained only in sleep.

9. Long continued mental activity produces an increased flow of blood to the brain, and necessarily causes a condition of wakefulness which is often distressing. Although there is a consciousness of mental weariness and a desire for repose, the tendency of blood to the brain often continues to stimulate it into action, and sleep is either disturbed and unrefreshing, or is prevented altogether. When the condition of wakefulness becomes chronic, it leads to nervous prostration, and the most serious mental disorder may follow. On the other hand, continued muscular effort will always be followed by a desire to sleep, from the fact that an extra amount of blood must be supplied to the muscles to admit of the increased work. Again, after taking food the processes of digestion demand that an increased supply of blood should go to the stomach and the intestines. In either instance the quantity of blood in the brain will be diminished and sleep thus induced. It is therefore a diminution of circulation in the brain that causes sleep, and not sleep that primarily diminishes the flow of blood to the brain, as has been sometimes claimed.

10. *Insomnia*. — In case of *insomnia*, or sleeplessness, it is much better to resort, whenever possible, to some physiological process that will cause sleep than to take medicines that will accomplish that result by diminishing the frequency of the action of the heart. A brisk half-hour walk will often change the flow of blood, divert it from the brain, and produce the required rest in sleep ; or an equal length of time spent in gymnastic exercises will probably prove effective. If muscular exercise fails, a

light meal will frequently accomplish the purpose better than medicine.¹ Physical labor often exhausts the muscular and the nervous systems to such an extent that an unusual demand for food is created. In this condition of exhaustion, sleep is often impossible; but if nourishment is taken, sleep follows promptly. The time-honored idea that it is *always* injurious to take food before going to bed is disproved by these facts. If, however, nutriment is not required, and no reason for taking food exists, it may be harmful; but it is always better to take a little food before retiring than to go to bed hungry.

11. When digestion is impaired and the liver becomes inactive, sleep ceases to be restful and refreshing. A dull brain and weakened nerves are the accompaniments in such cases. The processes of digestion and nourishment must be so improved that the tissue wastes may be replaced before sleep will bring the needed refreshment for brain and nerves.

12. **Pure Air.** — Fresh air in abundance should be admitted to the room during sleep. Impurity of the air respired during sleep conduces to impurity of the blood, and hence to the injury of the nervous system, which depends upon the blood for its healthfulness and vigor.

13. **Clothing.** — Too much or too little clothing during sleep, and at other times, proves injurious to the nervous organization by disturbing its functions. The quantity of clothing should be just sufficient to afford the required aid in the maintenance of the normal temperature of the body.

¹ Bathing the face with cold water will sometimes induce sleep, and the coolness of a pillow is a well-known inducer of drowsiness — the effects in both instances being to diminish circulation of blood in the brain.

14. Amount of Sleep Required. — As sleep is a wise provision of nature for regulating the waste and supply necessary for the continuous development of the forces of life, a proper amount of it, at regularly recurring periods, is necessary to sustain nervous energy. Many brain-workers habituate themselves to live with very little sleep taken at irregular periods, a custom which eventually, and as a rule, injures the general health.

15. The amount of sleep required naturally varies with the age of the individual. Children, in whom the supply must exceed the waste in order to provide for development, require long periods of sleep. Infants, if healthy, at first sleep three-fourths of the time; and all children under fourteen years of age should sleep not less than ten hours. From that age to maturity, all persons will undoubtedly be healthier if they sleep long and soundly. During the "prime of life," most people require at least eight hours sleep. Among many examples of vigorous mental and physical life, resulting from regularity of work and repose, may be mentioned Alfred the Great who divided his day into three parts, devoting eight hours to business, eight to study, and eight to sleep and recreation. It would, no doubt, be still better to increase the number of hours to be devoted to sleep and recreation. After middle age less sleep is required, as a rule, because bodily activity diminishes, and the same amount of repair is not required to build up the tissues. In extreme old age the individual demands usually a greater amount of sleep; the bodily powers, becoming weak and easily exhausted, require more frequent periods of rest. It has been estimated that at 4 years of age about 12 hours sleep are required; at 7 years, 11 hours; at 9 years, 10½

hours ; at 14 years, 10 hours ; at 17 years, $9\frac{1}{2}$ hours ; at 21 years, 9 hours ; at 28 years, 8 hours — the latter amount being a fair average for the healthy adult.

16. Experiment appears to indicate that the soundest sleep occurs within the first hour of repose, or soonest after the labor or exercise which may have induced it.

17. The activity of the brain manifested in dreams is probably due to the continued wakefulness of certain lower centres of the brain, the higher or intellectual centres being in a state of repose. Dreams of a remarkable or troubled character are usually the result of mental or physical over-exertion, or of digestive disturbance.

18. **Narcotic Sleep.** — All sleep-producing potions and narcotics are absolutely harmful under ordinary circumstances, and should invariably be rejected as such, except in serious emergencies under competent medical advice. Besides the appalling danger to life to which the deluded tippler of *morphia* and the drinker of *chloral* are subject, the use of these and similar drugs only increases the evils of brain or nervous excitement and sleeplessness which they are taken to alleviate or prevent. The dose which proved effective on the first occasion must be increased to produce an equal effect on the second, and so on with each repetition. A narcotic habit is developed from which there is frequently no escape, and ultimately an irritability of the brain and nervous system is produced which is fatal to the enjoyment of natural rest. In innumerable instances the habitual users of narcotics — opium, laudanum, morphia, chloral, alcohol, etc., have become mental and moral wrecks. The saddest results of the use of narcotics are the more or less speedy dethronement of the will and the moral degradation which follows.

19. *Alcoholic beverages* stimulate circulation in the brain, and thus prevent sleep till reaction takes place. Sleep that is thus produced is unnatural, and therefore unrefreshing. Tea and coffee taken with the evening meal or before retiring, produce sufficient brain-stimulus to prevent sleep, and they are sometimes taken for this purpose when special mental work is to be performed; but if their use in this way is continued, injurious results will follow. It is always a safe rule to avoid all beverages in the evening that tend to cause a loss of sleep; and no one who values a vigorous brain should consent to employ means of producing a narcotic stupor which, at best, is not nature's sweet restorer, balmy sleep.

20. **Rest in Exercise and other Recreation.** — Rest does not consist in mental and physical inaction alone. Absolute inactivity soon becomes irksome and a source of weariness instead of healthful rest. A change of employment in which other faculties of the mind or muscles of the body are called into action, while the weary or overstrained ones are allowed to recuperate, frequently affords precisely the quality of rest needed.

21. The development of physical as well as mental education in schools and colleges, and the attention which is being given to means of recreation among all classes of society, are beginning to be beneficial to health. Growing children and young people are not as capable of great or long-continued mental or physical employment as adults, and it is essential to health that they should not be kept too long at any one kind of work. Physical exercise of a well-regulated kind is invaluable in developing the bodily powers, and in affording relief from over-taxing mental work. It is gratifying to know that means for such exer-

cise are available and being employed by girls and women as well as by boys and men.

22. The great aim and end of exercise, as related to rest and recreation, is to provide relief from the duties and labors of the day. "The schoolboy's games are the antitheses of his school work, just as the walk of the merchant, the rowing, bicycling, or gymnastic exercise of the sedentary student, form an agreeable contrast to his ordinary occupation. It is this feature of alternation of occupation, combined with the bringing into play of a new set of muscles or thoughts, which constitutes the beneficial nature of all recreation. Even the desire for alternation which prompts the student of science to amuse himself with a novel, is an apt illustration of this truth."¹

23. Heredity. — Resemblances in the structure and workings of internal organs of the body are inherited, just as resemblances in external form and feature descend in families from parent to child; and thus it is that tendencies toward certain diseases are frequently inherited. This inherited tendency is probably most prominent in nervous diseases, such as epilepsy, St. Vitus dance, and the various forms of insanity. While none of these diseases is necessarily hereditary, the tendency toward them is common, and is greatly increased if a certain disease affects both parents.

24. Under ordinary circumstances, the prospects of health in one subject to such hereditary tendency to disease would be discouraging. Fortunately, however, just as medical experience shows that if a child whose parents are consumptive is carefully fed, guarded against cold, warmly clothed, caused to breathe fresh air, and kept from

¹ Wilson's "Manual of Health Science."

over-strain, he may live to ordinary old age, so may one born of parents who are afflicted with nervous disorders or insane tendencies. By means of well-directed education and restraint, together with careful attention to physical health and avoidance of nervous over-strain, similar escape may be made from the malady to which he is heir. It will thus be seen, that although disease may be inherited and "like begets like" as a rule, there is yet a law which, if observed, results in modifications of, and departures from, the tendency to inherit either mental or physical disease.

25. Alcoholic Drinks as Related to Nervous Diseases and Insanity. — The primary effects of alcohol, when taken in small quantity, is to induce excitement of the brain and other nervous centres, causing a temporary stimulation of mind and a feeling of brightness and cheerfulness. The nerves of the muscles are similarly excited, and, for a short time, there is a general feeling of mental and muscular vigor. When the quantity is larger, or the small doses are more frequently repeated, this initiatory condition is followed by intoxication terminating in reaction whereby nerve and muscle become paralyzed, and narcotic depression or stupor supervenes. These effects illustrate the stimulant and the narcotic action of alcohol.

26. Alcohol introduced into the body is distributed by the circulation of the blood, and comes in contact with the brain and other nervous substance. Having a strong affinity for water, it absorbs moisture from nerve-tissue and paralyzes its action. This effect upon the nerve extremities unfits them for their offices to such an extent that they become less sensitive to impressions, and less capable of carrying impulses and reporting to the

brain true external conditions. Thus sight, hearing, taste, smell, and touch become dulled and uncertain, and the action of the muscles weakened and unreliable. The great nervous centres are similarly affected, and are rendered more or less incapable of performing their controlling functions. Frequent intoxication, or continual use of alcoholic drinks, may produce a degeneration of the structure of nervous matter sometimes seen in softening of the brain, or in other forms of general paralysis.

27. While it is true that the effects of alcohol are not uniform or equal in different persons, its properties as a narcotic are such as to lead generally to the use of gradually increasing quantities, and to ultimately induce one or all of the effects stated.

“Whatever affects the character of the nervous tissue affects the power to feel and to judge correctly of external conditions, together with the power to control the motions of the body.” Feeling, sensation in general, and mental soundness are directly determined by the condition of the nervous system.

28. Aside from the question regarding the exact nature of the action of alcohol on nerve substance, it is certain that its general effects upon the mind are sooner or later as follows : (1) Confused and imperfect perception of sensation ; (2) the memory becomes less clear and less retentive ; (3) the imagination is either unrestrained or torpid ; (4) the intellect and the power to reason are weakened ; (5) the finer sensibilities are blunted, and self-respect is more or less lost ; and (6) there is loss of will power and self-control. The latter effect constitutes the most serious and alarming consequence of the demoralization wrought by alcohol on the mind, indicating as it does

the establishment of a morbid and ungovernable narcotic appetite, an irresistible craving which alcohol or any other narcotic tends to create.

29. The mental defects just stated as due to the action of alcohol are closely related to insanity. When the nervous system is partially paralyzed, the vital processes disturbed, and the mind so deranged as to display the weakness mentioned as resultant from alcoholic action, there is a greatly increased liability to be strongly affected by other causes that tend to produce insanity.

30. That alcoholic intemperance is one of the greatest sources of insanity is proven by the statistics of various asylums in America and in Europe ; and it is further established by the vital statistics of the past fifty years in the United States that the great increase of nervous diseases, chief of which is insanity, is directly proportionate to the increased use of alcohol and other stimulants and narcotics.

31. **Baneful Effects of Opium, Morphia, Chloral, etc.** — Severe and prolonged attacks of pain, sleeplessness, or nervous excitement (especially that which accompanies or follows the excessive use of alcohol) frequently lead to the use of opium in some of its forms, or of chloral, etc., as a remedy. These are powerful and deadly narcotic poisons, and are extremely seductive in their first effects. Like all of their species, they beget a narcotic appetite which steadily increases, and stealthily fixes itself upon its victim. The habitual use of any of these results in paralysis of nervous force, and leads to mental and physical destruction. As they are only medicines, they have no safe use other than when prescribed by a wise and competent physician, under whose directions they may prove blessings, otherwise they may prove curses.

32. The Use of Alcohol as Related to Crime. — That the action of alcohol not only enfeebles the faculties of the mind, but also dulls the moral sensibilities, is clearly and painfully evident in every-day life. Carelessness or indifference as to right and wrong is gradually induced by its free use, and a path is thus opened which leads by easy steps to dishonesty and to the brutal crimes.

33. “The tendency of alcohol to paralyze the nervous system so that pain is no longer readily perceived, and to obscure the more delicate and refining sensibilities of the mental part, on the one hand, together with the inflaming character of alcoholic beverages upon the animal passions, on the other hand, put the individual in the very condition that favors evil action. . . . When to the obstructed intellect and excited baser propensities there is added the serious consequences upon the *will*, as seen in the inability for self-control, it seems to follow as a necessity, in the very nature of the case, that one who is under alcoholic influence would be more disposed to wrong than to right action.”

34. The practical illustrations of the effects of alcohol in the production and fostering of crime are usually so painfully familiar as to require no enumeration here. It is a well-known fact that in communities in which alcoholic liquors are freely used, riotings, disorder, and crime are most abundant. The statistics of prisons everywhere show the enormous proportion of cases of crime due to alcoholic drink ; and the statement is justified that at least three-fourths of all the crime committed is due directly to the evil effects of alcohol upon the human mind and body.¹

¹ A few of the many illustrations that may be quoted from the statistics of prisons are as follows : Of 14,315 inmates of Massachusetts prisons, 12,396, or 84 per cent,

In the crime of murder, the most serious known to the law, alcoholic influences have been estimated to apply in nine-tenths of the cases.

35. The Effects of Tobacco. — Tobacco is a brain poison. When it is recollected that tobacco deteriorates the blood, one-fifth of which constantly flows to the brain, it will be understood that the brain and nerves are necessarily affected. The effects of so violent a poison as *nicotine* in the blood interferes with the healthful action of the brain, and causes nervousness, languor, depression, uneasy sleep, and debasement of the intellect, especially in young persons. Like alcohol and the other narcotics, it begets a depraved appetite which the strongest wills often find it impossible to withstand, and the gratification of which becomes loathsome slavery. The tobacco habit once formed becomes a relentless master.

were reported as intemperate. The County Prison report of Philadelphia for a single year shows that of 13,171 persons committed to prison, 9,038, or 75 per cent, were intemperate. In other States and cities the percentage of crime caused by alcoholic drink is correspondingly large. In the reform schools for juvenile offenders a very large proportion of the boys are from homes in which one or both parents are addicted to alcoholic intemperance.

Suggested Points for Questions.

CHAPTER XXIV. — 1. Functions of nervous system — motion and sensation, mysterious force. 2-4. Divisions of nervous system — cerebro-spinal, sympathetic, constituents, distribution of nerves, functions of each — voluntary and involuntary — connection. 5-7. Nervous tissue — gray, white; functions of each; difference of structure — fibrous white, cellular gray; texture and amount of each. 8-11. The brain — what and where, arrangement of substances, seat of nervous force, intellect, etc.; average maximum and minimum weight, size compared with brain of lower animals; organization and texture govern capacity — comments; coats or membranes — location, structure, arrangement relatively, protection, fissure and hemispheres; divisions of brain. 12-17. The cerebrum — location, relative weight, hemispheres, substance arrangement, convolutions, interlacing fibres, crossing of fibres and injuries manifested, cross-action of hemispheres, motory and sensory impulses — conduction. Cerebrum principal seat of intelligence, will, voluntary motion, etc. Areas of distinct nerve-impulses; complexity of convolutions and intelligence — illustrations. Knowledge of functions — how obtained, effects of diseased cerebrum, effects of removal of cerebrum. Functions poorly understood, portions governing motion and sensation distinguished — experiments; central influence not yet recognized. Brain of the insane not suggestive, theories disputed. 18, 19. The cerebellum — location, unlike cerebrum, hemispheres and relative arrangement of matter, nature of convolutions, interlacing of gray and white — *arbor vitæ*. Functions attributed to cerebellum — co-ordination; effects of removal of cerebellum in animals — confusion; voluntary movement and the cerebellum — harmonious action; painless cutting. 20, 21. The pons varoli — location, structure — bond of union; functions — locomotion, a centre of touch. 22, 23. Medulla oblongata — what and where, gray matter; regulator of circulation, breathing, swallowing, etc. — involuntary action; importance as a conductor of impulses; vital nature — effects of injury.

CHAP. XXV. — 1-3. The spinal cord — location, extent, length, thickness, etc.; membranes and their arrangement — protecting sheath; right and left halves — union; arrangement of matter. Enlargements, spinal nerves — pairs; motory and sensory centre — general functions stated as similar in part to medulla. 4-7. Reflex action — result of severing spinal cord; effect of irritating limbs when disconnected from brain — absence of sensation and will. Reflex action defined; spinal cord a centre of reflex action — function

of gray matter. Constant occurrence of reflex action — action of vital organs, breathing, etc., examples. Effect of severing one side of cord — cross action; effect of severing lengthwise on motion and sensation; knowledge limited as to movements of impulses. 8. Nerves in general — nature of substance; structure — filaments, bundles and sheath, formation of large nerves, separation to form branches. 8-11. Sensory and motor nerves — each defined; mixed nerves — number and constituents; entirely sensory — examples. Power of nerves and of nerve-centres contrasted. Cranial and spinal nerves — origin, and passage through bones — pairs. 12, 13. Cranial nerves — number of pairs, arrangement; traceable to medulla — exceptions; include nerves of special senses, muscles of eye, face, vital organs, etc.; pneumogastric nerve — branches, functions, effects of disturbance; indicative names. 14-21. Spinal nerves — what and where; pairs, groups in regions of spine, *caudâ equina*; nerves of neck — distribution; of the back; of the loins; remaining pairs and distribution; sciatic nerves — nature and distribution. Roots of spinal nerves — differences in function; union into trunks, distribution. Sensation destroyed and motion retained — *vice versa* — proof of two orders of nerves, etc. What experiments on animals have demonstrated in irritation of nerve-roots — conduction of motion and sensation by different roots. Probable change in arrangement of molecules by irritation; result of experiments in irritating, cutting, and tying nerves at different points; a limb “asleep” — cause. Utility and importance of double function of nerves — muscular sense. 21-25. Sympathetic nervous system — location of central ganglia — connection with brain; beaded ganglia — distribution of nerves to organs; solar plexus. Functions of sympathetic system — anatomical union with cerebro-spinal and effect. Sympathetic ganglia involved in shock, disease, or injury of an organ — sympathy of action. Necessity of harmony between two systems; undue activity or lethargy of either — effects. Sympathetic system and the will — involuntary action. 26, 27. Nervous impulses — generation, explosion of nerve-force, resultant movement, velocity. Education of impressions; instinct of protection prior to education. 28, 29. The mind — what? The crowning function of cerebrum; the production of thought — theory; combustion of tissue in mental effort.

CHAP. XXVI. — 1-4. Primary requisites of nervous health — normal conditions and proper performance of functions of organs. Diseased organs and nerve-disorder. Work, recreation, and rest — importance. 5-7. Mental work — over-work and insufficient work — analogy of effect. Varied mental and physical labor — effect. Length of life in mental and in physical labor. Regularity important in work, rest, sleep — periodicity. Spurts of work and their effects — strains; break-down in severe temporary strains

frequent. 8, 9. Rest and sleep — feeling of weariness indicative after labor; unsatisfactory results of fatigued labor — nervous exhaustion; rest at proper time important; rest in temporary change of employment; complete repose. Mental work and circulation in brain — wakefulness, nervous prostration; muscular action diverts blood from brain — result; digestion diminishes circulation in brain — sleep induced. 10, 11. Insomnia — physiological relief best; physical action to divert blood from brain; influence of a light meal; exhausted nervous condition as related to sleep — food beneficial; eating before sleep not always harmful. Impaired digestion and sleep — improved condition essential. 12. Pure air in sleeping-rooms — impure air and the nerves. 13. Clothing during sleep — too much, too little; disturbance of nervous functions. 14–17. Amount of sleep required — regulation of nervous energy; little and irregular sleep — effects. Varying amount at different ages and why; Alfred the Great's division of time; less sleep after middle age — reason; extreme age and sleep; estimated hours of sleep required for health at different ages. First hours' sleep soundest. Dreams — probable condition of brain, over-exertion, indigestion. 18, 19. Narcotic sleep — potions usually harmful; evils of nervous wakefulness increased; increased doses, development of narcotic appetite — irritable nervous system; mental and moral wreck; will dethroned, etc. Alcoholic stimulation and reaction — sleep unnatural. Wakefulness caused by tea and coffee; vigor of brain and narcotic sleep. 20–22. Rest in exercise and other recreation — inactivity ceases to be restful; change of employment as rest; growing children and long-continued mental work; physical relief from mental work. Aim and end of exercise in relation to rest — analogies; alternation of occupation — philosophy of. 23, 24. Heredity — tendencies in mental health inherited — increased when disease affects both parents. Prospects of health in hereditary tendency; means of possible escape — law of modification. 25–30. Alcoholic drink, nervous disease, insanity — effect of alcohol on brain and nerve-centres — temporary stimulation, intoxication; reactionary effects on nerves and muscles — depression. Effects on nervous tissue — less sensitive and less capable as result; effects on special senses and on great nerve-centres — partial paralysis; softening of brain. Effects unequal in different persons; increasing use induced; judgment and feeling affected. General effects ultimately — perception, sensation, memory, imagination, intellect and reason, finer sensibilities, will-power, irresistible narcotic craving. Relation of effects to insanity — increased liability. Alcoholism one great source of insanity — proof by statistics; increase proportionate to use of narcotics. 31. Baneful effects of opium, morphia, chloral — inducement to use; narcotic poisons — seductive nature, fixed appetite, paralysis of nervous force, mental and physi-

cal destruction; as medicines. 32, 34. Alcohol and crime—dulled moral sensibilities—path opened to crime; animal passions inflamed; will and self-control enfeebled; free use of alcohol and riotings, disorder, and crime; the testimony of prison statistics—the crime of murder. 35. Effects of tobacco—a brain poison, nervousness, languor, depression, etc.

THE SKIN, CLOTHING, AND BATHING.

CHAPTER XXVII.

STRUCTURE AND FUNCTIONS OF THE SKIN.

1. **General Importance of the Skin.**—The skin is the outer covering of the rest of the body, a kind of garment or tunic which serves not only to protect the parts within and to add beauty to the exterior, but, while serving these purposes most admirably, it has other and peculiarly important functions. Since the skin is the most extensive excretory organ of the body, as well as the principal regulator of its temperature, good health depends greatly upon the proper performance of its functions.

2. “Unwonted depression and uneasiness, accompanied by loss of appetite and inability to sleep, are prevalent causes of complaint among many persons, and these conditions are commonly attributed to the weather. The relations which exist between such mental depression as constitutes *melancholia* and the defective discharge of its functions by the skin may help to explain the phenomenon.”

3. The connection of cause and effect may not be clearly made out ; but the fact remains, that when the skin does not act freely, when its functions are seriously im-

peded or arrested, melancholy broods over the mind ; and just as in the case of melancholia as a disease, the skin becomes dense and inactive. It is not a random conjecture, therefore, that cold and damp work their depressing influences mainly through the skin. In the interests of health-preservation, especial pains need to be taken to secure the freest possible action of this great surface of excretory glands. Warmer clothing, especially at night, frequent ablutions, with sufficient friction, and the promotion of skin activity by proper exercise, are obvious measures of health which everybody ought to understand and all should practise.

4. To fulfil its complex duties, the skin is composed of many parts, all harmoniously united into a single vast structure, which, constantly renewed from within, resists the agencies which as constantly tend to wear it away from without. Elastic and very resistant, it bears, without being torn, violent shocks and great pressure. In short, it at once protects, excretes, purifies, absorbs, and is the principal seat of feeling or touch. If in any way it is rendered unable in a considerable degree to perform its work, death results.

5. **The Layers of the Skin, etc.**—On examining the skin we find it to consist of two principal layers, an outer one called the scarf skin, cuticle, or *epidermis* (Gr. *epi*, upon, and *derma*, skin), and an inner layer named the true skin, *cutis*, or *derma*. These two layers differ in structure and functions, but adhere to each other and are intimately united with the underlying tissue by fibres which mingle with it. The skin of certain portions of the body appears to be loose and to slide over the parts beneath, as for instance on the back of the hand, front of

the neck, and about the joints: this it does by carrying along with it the more or less relaxed tissue. This suppleness can be most highly valued when the skin is altered by disease, as in the condition called "hide-bound,"² or when the affection called *eczema* has so changed its texture that the movements of a joint cause deep and painful cracks in the skin.

6. After enveloping the body, the skin becomes modified, and, under the name of *mucous membrane*, is the delicate internal skin which lines all the internal cavities; thus, the lining of the mouth, of the inner surface of the lips, and of the passages of the nose, is mucous membrane. Its structure and functions are closely related to those of the outer skin.

"There's a skin without and a skin within,
A covering skin and a lining skin;
But the skin within is the skin without
Doubled inwards, and carried completely throughout."

7. **The Derma, or True Skin.**—The *derma* is the thicker and tougher of the two chief layers of the skin: it is semi-transparent, and is composed of fibres which interlace so as to form an extremely resistant fabric resembling felt. The leather of commerce, from the thick, coarse sole-leather in which the felt-like fibres can be seen with the naked eye, to the softer and pliable calf-skin, and the still more delicate kid, is made from the derma, or true skin, of animals.¹

8. The under surface of the derma rests upon loose connective tissue, which unites it with the flesh or parts below. It is in this connective tissue that fat is deposited;

¹ The derma varies in thickness in different parts from a fiftieth to about a sixth of an inch, being thickest on the "small of the back." ² In horses.

and here water accumulates in dropsy. The upper surface is not smooth, but has myriads of little conical or rounded elevations, termed *papillæ* (Lat. *papilla*, a nipple), formed by the extremities of nerves and vessels. In certain parts of the skin the papillæ are scattered irregularly; while in other parts they are arranged in rows, and present the appearance of parallel ridges in the surface of the outer skin, especially where the sense of touch is very keen, as in the tips of the fingers and palms of the hands. The epidermis lies in direct contact with the derma: its under

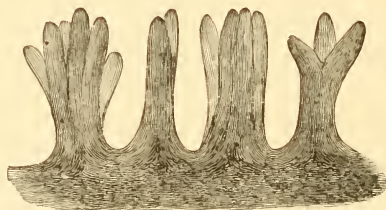


Fig. 49. — *Papillæ of the Skin from the Palm of the Hand. Magnified 60 diameters.*

The epidermis has been removed.

surface dips down between all the papillæ, and is accurately moulded to fit them.

9. In the derma are situated nerves, blood-vessels, sweat and sebaceous glands, and absorbent vessels, — organs whose functions will be noticed later.

10. **The Epidermis, or Scarf Skin.** — The epidermis, or *cuticle* (Lat. little skin), is a thin, transparent membrane, “a sort of organic varnish,” designed to come in contact with the air and external objects, and to protect the exquisite sensitiveness of the true skin. Unlike the derma, it is not composed of fibres, but of separate roundish cells, piled one upon another to a varying thickness in different

parts of the layer ; thus, upon the soles of the feet, palms of the hands, and wherever friction makes greater protection necessary, the epidermis is very thick.

11. Although the epidermis is in general so thin, it has been found to consist of an exterior, *horny* layer and two deeper ones. In the outer, *horny* layer, the composing scales are all flat, hard, and lifeless, only remaining to drop off, or to be washed or brushed away.

12. The middle layer, or *rete Malpighii* ("net of Malpighi"), so named from the anatomist who first described it, has round or many-sided, soft, moist cells which grow and develop to take the places of those constantly removed from the *horny* layer.

13. The third, or *pigmentary layer*, lies in contact with the true skin. It contains the coloring matter of the skin, a black or brownish substance which is more or less abundant according to the individual or the race to which he belongs, and which contributes to the variety of complexion seen in people of the same race. If the epidermis were removed, the surface of the body would be almost blood-red, owing to the many blood-vessels of the derma, or true skin. Where the epidermis is thickest, as upon the palms and the soles, there is but little red ; but where thinnest, as in the lips and cheeks, we have the bright pink caused by the blood-vessels of the derma showing through the outer skin.¹

¹ "When there are discolored marks on the skin, as in freckles, moth-patches on the face, etc., the color deposit takes place in this deeper layer of the epidermis ; hence, they are very difficult of removal, because, in order to take away all the coloring matter at once, this portion of the skin would have to be removed down to the papillæ, as in the case of blister. Now, this is painful and troublesome ; and, moreover, experience shows that it would be useless to blister off such deformities, because we not infrequently see blisters on different portions of the body followed by staining of the skin, where no such staining existed previously. We can, however, not infrequently,

14. The epidermis contains no blood-vessels, but its cells draw nourishment from the portions beneath. When subjected to much friction or to heat, it puffs up into a *blister* from a rapid accumulation of water underneath it; and when this outer layer only is removed by slight burns, abrasion, or disease, no scar is caused; but if the derma also is injured or destroyed, a scar is formed. In water-blisters, "cold-sores," "shingles," and "chicken-pox," the epidermis forms the covering; and when removed, no matter how sore and weeping the surface, if the epidermis alone is destroyed, it heals without scars.

15. **Muscles of the Skin.** — Certain of the lower animals — for instance, the dog, horse, etc. — have a large development of muscle just below and connected with the skin, so that they may wrinkle or shake it and thus rid themselves of insects, dust, or moisture. In the human skin such muscles are only slightly developed, and are found in but few parts; still it has a certain amount of muscular structure connected with its organs or glands.

CHAPTER XXVIII.

STRUCTURE AND FUNCTIONS OF THE SKIN (*concluded*).

1. **Vessels, Nerves, Glands, etc.** — In order to accomplish its complex work as a protector, purifier, absorber, regulator of bodily heat, and custodian of the sensations of touch, pain, etc., offices so vitally important to the body,

by proper stimulants, induce an absorption of the pigment, or produce rapid change in the skin, when the new-formed cells will not have the color." — *The Skin in Health and Disease*, by L. Duncan Bulkley, M.D.

the skin has numerous blood-vessels, glands, and nerves, each class of which is responsible for the performance of a special task. All are as busily employed as are the operatives in a vast factory. Only when the skin becomes diseased, or is abused by neglect or ill-treatment, do any of its organs cease from their labors during life.

2. In the skin the work is carried on by *nerves*, *capillaries*, *sweat-glands*, *sebaceous glands*, and *absorbent tubes* or *lymphatics*.

3. **Capillaries.** — The true skin, or derma, is very abundantly supplied with blood; even a fine needle cannot enter it without drawing blood from one or more of the extremely small branches of the arteries (the capillaries) which spread out in it. The capillaries rise into each of the little elevations (papillæ) of the upper part of the true skin, and, doubling upon themselves, descend and become veins which ultimately convey the blood back to the heart and lungs.

4. **Nerves of the Skin.** — The nerves of the skin are extremely numerous, as we may know from the fact that the point of the finest needle on entering the skin is certain to find one of them. Certain of the nerves are specially sensitive to heat and cold, and give the sensation of pain;

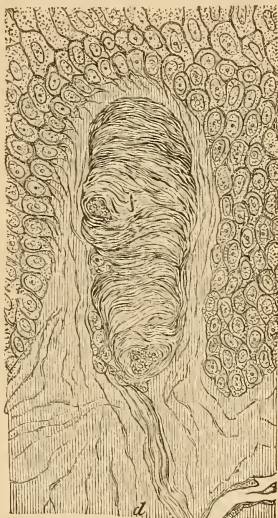


Fig. 50. — Section of the Papilla of the Skin, showing a Touch Corpuscle. Highly magnified.

EXPLANATION.

t, tactile, or touch corpuscle; *d*, nerve-fibres passing up to it.

but a somewhat different class are nerves of touch. This latter class enter the papillæ of the true skin, and wind up into little knots called *tactile corpuscles*; i.e., "little bodies of touch-power," because the sense of touch is supposed to reside in them. These nerves are found to be about one-fourth as numerous as the papillæ, being most numerous in the finger-tips and palms of the hands, but are found in less numbers over most of the body.

5. The great nerve-supply of the skin is undoubtedly for the purpose of protecting the body against injury. Endowed with exquisite sensibility, the skin suffers pain before the deeper parts can be reached, and thus a danger signal is given which often prevents serious or fatal results.

6. **The Sebaceous Glands.**—The *sebaceous* (from Lat. *sebum*, fat or tallow) glands, or oil-glands, are minute sacs situated in the derma. They vary from $\frac{1}{16}$ to $\frac{1}{2}$ of an inch in diameter in different parts of the skin, and are grouped about the deeper ends of tiny tubes or ducts, at the roots of the hairs. They secrete and pour out a whitish, oil-like substance which, in a healthy condition, is perfectly fluid at the temperature of the body. Very few of them open directly upon the skin; almost invariably they are connected with the hairs, and their ducts empty into the hair pits or *follicles*, from which the sebaceous matter runs out along the hair to the surface of the body. Generally there are two to each hair, but sometimes large hairs have several around them, forming a kind of collar.

7. The quantity of matter secreted by the sebaceous glands is not very great, and their main function appears to be to keep the skin soft and flexible, and to supply a natural dressing for the hair.

8. When there is disorder of these glands, and they fail to act freely, the skin becomes dry and hard. Sometimes the secreted matter thickens and hardens in the ducts, forming what are commonly, but improperly, called "skin-worms." At other times, when the ducts are obstructed and the glands go on secreting, a swelling, pimple, or boil is formed, and inflammation continues till the contents of the sac burst forth or are liberated by the prick of a needle.

9. Surplus sebaceous matter, together with the dead scales of the epidermis which adhere to it, are constantly removed from the skin, if it is properly cared for; but neglect allows this refuse matter to accumulate and clog the openings of the sebaceous glands and also of the sweat-glands, thus throwing their excretory work upon other organs, and causing slow disease.

10. **The Sweat-Glands.** — The sweat-glands are situated in the deepest portion of the true skin, or derma, or in the loose connective tissue just beneath it. A sweat-gland consists of a little coiled mass or ball of tiny tubing, from which a single tube or duct extends upward through the entire thickness of the skin and opens upon the surface. In passing through the derma, the duct takes a nearly

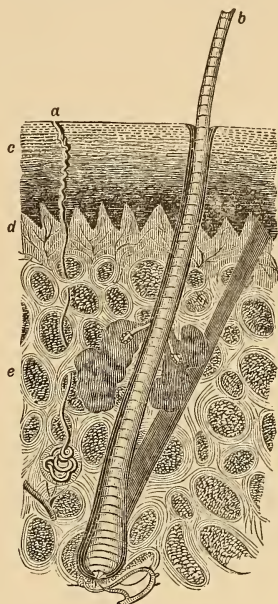


Fig. 51.

EXPLANATION.

a, a perspiratory tube with its gland; *b*, a hair with a muscle and two oil-glands; *c*, cuticle; *d*, the papillæ; and *e*, fat-cells.

direct course; but through the epidermis it makes a number of spiral turns, resembling a cork-screw.

11. The openings of the ducts are arranged quite regularly upon the surface, especially on the palms of the hands and soles of the feet, where, by aid of a microscope, they may be seen in rows between the slight furrows of the skin. The tube of each little gland is about $\frac{1}{400}$ of an

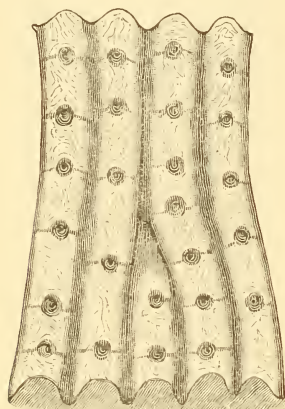


Fig. 52. — Magnified View of the Epidermis, showing the Pores.

inch in diameter; and if it were uncoiled and straightened out, it would be about $\frac{1}{15}$ of an inch long. Careful computations have fixed the total number of the sweat-glands at nearly 2,400,000; and hence their united length would be about two and a half miles.

12. In some parts of the skin these glands are very numerous; on the palms and soles there are about 2,700 in each square inch, and on the forehead about 1,250 in equal space. In other parts they are less numerous; the cheeks have but 550 in a square inch, while the neck and back have still fewer. Surrounding the sweat-glands is a network of capillary vessels, and from the blood in these vessels water and refuse matter in the form of carbonic acid, fatty acids, ammonia salts, etc., are filtered into the glands and cast out through their ducts. This water and these impurities constitute the *sweat*, or *perspiration*.

13. **Forms and Quantity of Perspiration.** — The sweat-glands secrete constantly, and under ordinary circumstances the

sweat is given off in so small an amount that it does not collect in drops, but evaporates as soon as it reaches the surface. This is called *insensible perspiration*, because it is not perceptible by sight or by touch. It is only when the body is exposed to a high temperature or heated by exercise that the perspiration manifests itself to sight and touch, and becomes what is termed *sensible perspiration*.

14. Though the glands are very small, their great number gives a vast secreting surface, and their millions of ducts pour out fluid nearly equal in quantity to that sent out by the kidneys. The amount of perspiration within a given time varies according to the temperature and moisture or dryness of the air, amount of exercise, quantity and quality of food and drink, etc. Results of careful experiments agree, however, in placing the daily perspiration in the average person in good health at two pounds, or two pints; and yet half of this quantity may be shed in a single hour of vigorous exercise or of exposure to a high temperature. Excessive perspiration is followed by great thirst, the blood demanding water to take the place of that which it loses.

15. **Absorption through the Skin.** — The skin has the property or function of absorbing various substances applied to its surface, and absorption takes place most readily in those parts where the outer or horny layer of the epidermis is thinnest. Medicines are sometimes administered, and produce their effects upon the system, by being rubbed into the skin. Thirst is considerably relieved by a bath, and it is even possible to supply nourishment by absorption through the skin. Children, when so much exhausted by disease as to be unable to eat, or whose stomachs refused to retain food, have been saved from

starvation by rubbing nourishing substances upon the surface of the body. In all these instances, particles absorbed pass into the blood.

16. Respiration or Breathing through the Skin. — It may be surprising that we breathe through the skin; yet a certain amount of what might be called respiration goes on through it. Experiment has shown that the skin absorbs oxygen and gives off carbonic acid. In an experiment made by Aubert, a person was enclosed in an air-tight case, leaving only the head exposed. By proper appliances the enclosed air was tested and found to contain less oxygen, while it had gained .05 per cent as much carbonic acid as was given off by the lungs in an equal time, thus proving that these gases are interchanged not only by the lungs, but through the skin also.

17. Functions of the Skin, Lungs, and Kidneys compared. — The functions of the skin are, therefore, similar to those of both lungs and kidneys. Like the lungs, the skin absorbs oxygen and gives off carbonic acid, water, etc.; and like the kidneys, it excretes both water and saline matter. The skin is, however, more closely related to the kidneys than to the lungs; and in hot weather, when the excretion by the skin increases, that of the kidneys diminishes — the reverse being true in cold weather.

18. When the free action of any one of these organs is interrupted, there is usually a tendency to throw its work upon the others; but this mutual aid goes only a little way without serious results to health. If, for instance, the kidneys become unable to perform their work, death results, no matter how active the skin may be; and on the other hand, if the skin were coated with an impenetrable varnish, death would soon follow, even though the

lungs and kidneys continue their work.¹ It is not uncommon that burns or scalds which destroy large portions of the skin, though not injuring deeper parts, result fatally. The importance, therefore, of taking proper care of the skin can hardly be overestimated, since neglect may result in clogging the many pores through which a vast amount of fluid and waste matter passes out of the system.

CHAPTER XXIX.

REGULATIVE AGENCY OF PERSPIRATION.

1. Perspiration and Heat. — Besides its work in casting out waste and impure matter from the blood, etc., the skin has an important function to perform in aiding to maintain a uniform temperature in the body. Thus while heat is constantly being generated in the body, the skin is radiating, or giving it off, at the surface. By a proper balance of these two processes, the temperature of the interior of the body in health is kept uniformly at about $98\frac{1}{2}^{\circ}$ Fahrenheit, though the standard varies $\frac{1}{2}^{\circ}$ or 1° with the time of day or night and with the sleeping or waking state.²

¹ When animals have the hair shaved off and the skin completely covered with an impenetrable coating, as by varnishing the surface, death always takes place; and the story is current among physiologists that at the coronation of Pope Leo X. (1475-1521), a little boy was covered with gold-foil, or gilded, to represent a cherub. He became ill almost immediately, however, and died in a few hours after the ceremonies, because the gold-leaf and varnish prevented the action of the skin.

² On the surface some parts are, of course, cooler than others according to the exposure to the air in contact with them. The average normal temperature of the surface is about $98\frac{1}{2}^{\circ}$, and is ascertained usually by placing the bulb of a thermometer in the arm-pit.

2. When the body becomes heated by exercise or by exposure to hot air, the *vaso-motor*, or vessel-moving nerves, which control the muscular coats of the blood-vessels, become affected and allow the capillaries of the skin to expand, thus inducing an increased flow of blood into them. This increase of blood in the capillaries causes the sweat-glands connected with them to act or secrete more rapidly, and to immediately pour out an increased quantity of warm perspiration from the blood. Evaporating from the surface and giving place to more from the interior, the perspiration abstracts heat and keeps the temperature of the blood at its proper degree. The greater the quantity of water thus evaporated the lower the temperature of the body would be if the heat-making process within was not going on at the same time.

3. **Perspiration and Cold.** — Cold, on the contrary, acts upon the *vaso-motor* nerves in such a manner that they over-stimulate the muscular coats of the small blood-vessels of the skin and cause them to contract, and thus diminish the size of the vessels. The blood is not only driven out of the blood-vessels in this way, but the ingress of new blood is prevented; and, consequently, the sweat-glands having less blood in contact with them, secrete and send out perspiration much more slowly. Evaporation from the skin being thus diminished, the radiation or loss of heat is correspondingly lessened.¹

4. We readily “catch cold” when this vast evaporating surface is exposed to a sudden lowering of temperature in a draught of air, or when too thinly clad. As a learned

¹ When the blood at the surface of the body, that is, in the skin, has become cool at a rate too rapid to be compensated by the production of heat in the interior of the body, death from freezing occurs.

physician has pithily remarked, "Of course, as this blood which is driven away from the surface must have some place to go to, it flows inwards to the warm parts of the body, filling them too full of blood, or, as it is called, *congesting* one or more of the vital organs. Whichever of these happens to be our 'weak spot' is, of course, least apt to recover promptly from the temporary congestion, and the most liable to become the seat of serious inflammation. If, for example, a man's lungs are his weak point, inflammation of the lungs, called pneumonia, running on, if neglected, to consumption, may be the result, etc." Other results may be pleurisy, bronchitis, rheumatism, bowel and kidney trouble, with their dangerous or fatal effects, all resulting from sudden chill and checking of perspiration.

5. When the bodily temperature is lowered, say to eighty degrees, death occurs as by freezing.

6. **Perspiration and Dry Air.** — When air is warm and dry, it is in condition to absorb much moisture, and hence perspiration evaporates very rapidly into it. For this reason, a man perspiring freely may remain without injury for a considerable length of time in an oven where meat could be cooked. It is related that the workmen of the sculptor, Chantry, were accustomed to enter a furnace in which the temperature stood at 350° ; and that Chabert, a public performer who styled himself the "Fire King," remained in an oven heated to 600° while a beefsteak was cooked beside him! Men employed in iron-working establishments, for instance at "puddling" furnaces where the heat is intense, sprinkle themselves with water, and thus add moisture to be evaporated from the skin. In all these instances, the dry heat of the air is expended in

changing the abundant perspiration or water into vapor, and the temperature of the blood is but slightly raised.

7. **Perspiration and Moist Air.** — Very moist air, on the contrary, already contains so much watery vapor that it is unable to absorb much more — sometimes none at all — and at a high temperature it causes great physical discomfort. The perspiration pours out upon the skin, but remains there unevaporated and fails to cool the body. A temperature of 80° on a “damp day” may, therefore, cause more discomfort than 90° causes when the air is dry. Thus it is that men endure the intense dry heat about puddling and smelting furnaces, but cannot as easily bear a lower temperature in the moister open air of a hot day. Exposure to a moist atmosphere at a high temperature, especially if vigorous exercise is being taken, is apt to cause what is called “sun-stroke,” or “heat-stroke,” in which case the temperature of the blood mounts to about 113° , and quickly proves fatal unless relieved by cold.

8. **The Hair.** — The hair, as well as the nails, may be regarded as an appendage of the epidermis, so changed in structure as to fulfil special offices. A hair consists of two parts, the *root* and the exposed part, or *shaft*. The root is somewhat pear-shaped, and is situated in a little pit or sac, called a *follicle*, deep in the derma, or true skin. At the bottom of each pit is a little projection, or *hair papilla*, which extends into the root of the hair, and from it come the materials for the growth of the hair, there being a minute blood-vessel in its interior. Even when “plucked out by the roots,” hair will be reproduced if the little papillæ are not destroyed, and remain in a healthy state; and therefore superfluous hair can be kept from growing only by destroying the life of the hair papillæ.

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9. Through the centre of each hair, from end to end, runs a canal filled with cells which contain the coloring matter of the hair. In diameter, hairs vary from $\frac{1}{1500}$ to $\frac{1}{100}$ of an inch on different parts of the body, the average diameter being about $\frac{1}{450}$ of an inch. Dark hair is usually coarser than light hair, and flaxen hair more abundant than darker shades. It has been estimated that the number of hairs on the average head is about 120,000. Few, if any, hairs are round, and they are so elastic as to stretch nearly one-third of their length. The substance of hair is very enduring.¹

10. The hair is useful in various ways: that on the head protects it from extremes of heat and cold, and the eye-lashes and hairs of the nose and ears protect those organs from dust, insects, etc.

11. **The Nails.** — The nails are composed, much like the epidermis, of hard, horny matter arranged in cells. They lie upon a bed or *matrix* (from Lat. *mater*, mother), just as the scarf-skin rests upon the true skin. They grow in length by constant addition of cells at the *root*, and thus push forward over the matrix. Cells are deposited on the under surface of the nails by the matrix, causing them to be thicker at their forward ends than they are at the roots.

12. An injury to the matrix, or bed of the nail, such as from splinters driven under the nail, or even from severe bruises, need not cause a disfigured nail except at the immediate point of injury; but injury or disease at the root generally causes distortion of the nail. Certain dis-

¹ A remarkable illustration of the enduring character of human hair may be seen in the British Museum, where has been placed a wig, lately found in a temple at Thebes, which is supposed to have been worn by an Egyptian priest at a period not less than 3,400 years ago.

eases of the skin extending to the back of the fingers sometimes involve the roots of the nails, and cause ill-growth. The growth of the nails is often arrested by sickness which interferes with the deposit of nail-making material, and the portion of a nail grown during sickness is often perceptibly thinner than that which is formed during health. Nails themselves are subject to diseases; and as age advances, they gradually become harder and brittle.

13. The use of the nails is to protect the sensitive finger-tips, and, by serving as a firm backing, aid the sense of touch in them and assist in picking up minute objects. They also preserve the symmetry of the fingers; for, when the nails are kept too closely trimmed, the fingers are apt to become "club-ended."

CHAPTER XXX.

CARE OF THE SKIN. — BATHING.

1. **Hygiene of the Skin.** — The hygiene of the skin requires a consideration of two chief questions: 1st, how, in caring for the skin, to cleanse it from impurities; and 2d, how to assist it in regulating the temperature of the body; the former by *proper bathing*, the latter by *proper clothing*.

2. **Cleansing of the Skin Necessary.** — The millions of "pores" of the sweat and sebaceous glands pour out a great quantity of matter, some of which, becoming mixed with the loose, bran-like scales of the scarf-skin, dries and remains

fastened to the surface of the skin, clogging the mouths of the pores and interfering with the action of the glands. A laboring man perspires freely, his flannel shirt chafes his skin, and thus removes much of the matter deposited upon it; but a person of less active muscular employment, or one who lives a sedentary life in warm rooms, is accumulating upon his skin a dangerous form of matter *brought to it for removal*.

3. Poisonous matter left upon the skin may be absorbed into the blood and cause disease. Careless painters, mirror-silverers, and workmen in lead factories are frequently poisoned by lead or by mercury absorbed through the skin.

4. It has been well-said: "If the vital fluid, the blood, becomes impure and stagnant from a burden of waste matter which should, but cannot, escape from the skin, or which has been carried there to be discharged only to find the outer door shut, and then has become absorbed by the scavengers of the body, is it surprising that the individual feels depressed and inactive, and that he has a poor appetite and aching head?"

5. It will be readily understood, therefore, that in order to have a healthy skin or a healthy body, to escape lassitude, headache, and feverishness, the skin must be kept clean and free from all accumulations. It has been said that "cleanliness is next to godliness."

6. **A Warm Bath for Cleanliness.** — For purposes of cleanliness, warm baths—those in which the temperature of the water is from 70° to 80°—are the best. Water of this degree of heat usually gives an agreeable sensation of warmth, avoiding the shock of a cold bath (one below 60°) and the excessive stimulation of a hot bath (one of 85°

and upwards). It is well to recollect that a warm bath is all sufficient for cleanliness, and is not a hot bath: the latter should be reserved for cases of great fatigue, the first stages of a cold, etc.

7. *Care should be taken not to remain too long in a warm bath*, as such a practice has a very weakening effect when often indulged. As a general rule, ten to fifteen minutes are long enough for a warm bath.

8. *The skin should be perfectly dried by friction with towels or with bath-mittens on emerging from a warm bath*, because, as it is full of blood and in a relaxed condition, exposure to cold air, or even to drafts of warm air, is dangerous.

9. *The frequency with which a bath should be taken varies* considerably with the person. Some whose skins send out very large quantities of strong-smelling perspiration may require a bath daily, or even twice daily, in warm weather. It is a safe rule in health, to which there are exceptions of course, to bathe the whole body twice a week in winter, and every other day in summer. The frequency may be increased gradually to three times a week in winter, and to a daily bath in summer. While bathing may be carried to an injurious excess, it is certain that the majority err in the opposite direction.

10. *The best time for taking a warm bath*, for those who easily take cold, is at night, just before retiring. Going to bed at once, they avoid exposure for a number of hours after the bath. Unless a person can stay in-doors several hours after taking a warm bath, it should *never* be taken in winter before the bed-hour.

11. *Baths should never be taken immediately after a meal*, as the change in the circulation of the blood caused by a

changed temperature of the surface of the body interrupts the work of the digestive organs ; thus, for instance, if the blood is attracted to the surface of the body in large quantities, the temperature of the stomach will be somewhat lowered and its work will be delayed. *At least three hours should elapse after a meal* before a bath is taken.

12. *Soap is necessary to remove the fatty matter poured out by the oil-glands.* However, the soap used in bathing should not be too strong, — that is, should not contain too much alkali. There are very great differences in soaps and in their effects upon the skin. The common yellow bar soap and ordinary soft soap are stimulating and very irritating to tender skins, and are apt to remove the oil of the skin so effectually as to leave it dry and roughened ; but old, white Castile soap, made from olive oil and soda, and some of the best toilet soaps, have little, if any, bad effect, while they serve to cleanse the skin.

13. The cheap scented and colored soaps often have clays, etc., mixed with them to increase the bulk and cheapen the cost, and are too frequently scented, colored, and gotten up showily for the purpose of disguising the impure and irritating material which they contain. Cheap soaps are often made from poor oil or fat, and have been known to contain bits of bone, decaying matter, and even pus globules : such soaps have caused skin diseases and eruptions on the face when used in shaving. Too much care cannot be taken in selecting a toilet soap, as a “cheap” one may prove to be a very dear one.

14. Hot Baths. — Hot baths are very stimulating to the skin, and are of excellent service in case of great weariness. They are also an effective means of breaking up a cold in its first stages ; that is, when the skin first becomes chilly

and "sore to the touch." After a hot bath of two minutes, the skin should be rubbed thoroughly dry — care being taken to prevent its exposure to cold air or to drafts of any kind — and the person should *retire to bed immediately*. The hot bath, a drink of hot lemonade or even of cold water, and wrapping the body in a warm blanket in bed, will be quite certain to make the glands active, open the pores, and drive out the cold with the perspiration. But hot baths are much less safe for ordinary bathing than those of a more moderate temperature; because when frequently employed they are weakening, and the liability to take cold afterwards is very great.

15. Cold Baths. — The first effect of cold water brought into contact with the skin is the same as that of cold air, or of any other cold when applied to it. The nerves receive a shock which causes a contraction of the blood-vessels of the skin, and the blood is driven toward the interior of the body, and the lungs and heart are stimulated to increased action. If the heart is vigorous, it soon sends the blood rebounding to the surface; and by this reaction the skin becomes rosy and a pleasurable warmth is felt. *While this glow continues the bath should end*, else a feeling of weakness and depression will follow, and may last during a number of hours or an entire day. To increase the glow and the good effects of the bath, the skin should be rubbed briskly with towels or with bath-mittens.

16. If reaction does not set in promptly, the effects of a cold bath are evil. When the heart is not vigorous, the bath may fail to stimulate its action enough to drive the blood back toward the surface. In this case, the blood over-crowds various internal organs, and, by remaining too long in them without proper circulation, becomes stagnant

and impure. Thus, from over-fulness of blood the brain may become dull and confused, the lungs oppressed, the stomach nauseated, and the liver interrupted in its work. If the cold bath be taken at a proper time and in a proper manner, and reaction still fails to take place promptly, the bather may conclude that a cold bath injures him.

17. Sea-Bathing. — Salt-water baths are more stimulating than fresh-water baths, and, when properly taken, are one of the best means of strengthening the system. In cases of weakness from rapid growth in young people, the sea-bath is almost always of great benefit. Persons of very nervous temperament, and those who suffer from any acute disease, as, for instance, disease of the valves of the heart, should be very cautious in resorting to cold- or sea-baths; in fact, all invalids will find it much safer to take competent medical advice, and obtain explicit directions as to when, how long, and how often to bathe, if at all.

18. In taking a surf-bath, it is best to run or walk rapidly into the water, and dip the whole body, head included; or to allow a wave to dash over and wet the entire person at once. One should be *comfortably* warm on entering the water, and should exercise actively while taking the bath, thus causing the temporary chill to give place to a glow which may be increased by thorough rubbing. The first shock is usually followed by a return of warmth which continues for a time and is again followed by chilliness. This second chilliness is a danger-signal, and the person should leave the bath *instantly*; but better still, leave it before the second chill begins. Many persons who are not strong enough to endure the shock of a surf-bath find a cold "still-bath," or a bath in warm salt water, both agreeable and beneficial

19. Robust people may bathe twice a day in the sea without harm ; but for most persons a bath once a day is sufficient. For reasons already given, a bath should *never* be taken soon after a meal ; and thorough drying and friction of the skin is as necessary after a sea-bath as in other bathing. In order that the good effects of sea-bathing shall not be counteracted, it must be recollected that care in diet and in other hygienic matters is as necessary at the seashore as elsewhere.

20. **Friction Baths.** — In the morning, before breakfast, the body is least able to react from the chill of the ordinary cold bath. Many hours elapse between the time of the evening meal and breakfast, and meanwhile the fires of the body burn low from lack of fuel (food) ; the “ river of life ” flows sluggishly, and the system is not in a condition to meet best the effects of a full bath, either cold or warm.

21. *A wet friction bath*, however, may be taken before breakfast, even in winter, without endangering health. Such bath may be taken in the following way : “ Procure a pair of mittens of hair, crash, or any rough, coarse material. Wring them out in cool water, and rub trunk and limbs quickly, but not violently. There should not be a drop of water visible on the skin. Wipe off the moisture with a soft towel, and repeat the rubbing with dry hands.” This bath is highly beneficial except, probably, to actual invalids, and produces a glow and a delightful feeling of stimulation.

22. *A dry friction bath* is simply an air bath in which friction of the skin is employed, and it may be taken as follows : Remove the clothing, expose the body to the air, and use the *dry mittens* as in the wet friction bath. The

roughness of the mittens may be increased by saturating them with a strong solution of salt and water, and then drying them to be ready for use.

23. Friction of the skin while it is exposed to the air has a tonic effect ; and either the wet or the dry friction bath has a beneficial effect on the wearied body or jaded brain. When taken at night, a friction bath is sleep-producing, for it calls away the over-plus blood from the brain, and relieves it from pressure which is a common cause of restless wakefulness.

24. Washing of Face and Hands. — Cosmetics. — The skin of the face and hands is washed or bathed more frequently than that of other portions of the body ; and if strong soap is used often, the natural oil will be removed so completely as to make the skin too dry, and call for the application of grease, vaseline, etc. It is best to use soap only when necessary to remove impurities that refuse to yield to water alone. In winter, particularly, the skin of the face and hands should be perfectly dried after washing before exposure to cold air ; for a sudden contraction of moist skin by exposure to cold air cracks the outer layer, and these cracks extending to the true skin become very painful.

25. Cosmetics and powders for the skin frequently contain poisonous ingredients, such as large quantities of lead, and many of them are known to be injurious to the skin and to cause disease : they should be avoided as a class, no matter how seductive their advertisement. As their composition is commonly unknown, those who value health and beauty of complexion should not allow themselves to be tempted to try them. If, as is sometimes the case, the skin of the face is very greasy, pure *rice-powder* or a little

calcined magnesia will absorb the oily matter and be quite harmless. Daily moderate friction of the face with a towel aids greatly in keeping open the ducts of the sebaceous glands, and does much to prevent the formation of black specks ("skin-worms") and red blotches so common on the faces of young persons.

26. The most effective beautifiers of the skin are judicious washing or bathing, pure air and exercise, a careful diet,¹ and avoidance of alcohol and tobacco.

27. **Care of the Scalp. — Hair-Dyes.** — The scalp should be kept clean and its pores unobstructed. Here, as elsewhere, the scarf-skin is being shed constantly; and if its scales are allowed to remain and combine with drying sebaceous matter, they constitute what is called "dandruff." Sometimes an unhealthy secretion of the sebaceous glands is seen as a greasy coating upon the scalp, or in the form of yellowish, greasy scales. While dandruff does not "eat off the hair," the conditions that tend to produce it should never be neglected, because they are attended, sooner or later, with baldness. The hair and scalp should receive a daily brushing with a comparatively soft brush. A fine-toothed comb, while giving temporary relief from dandruff, will irritate the skin and aggravate the difficulty. The scalp should be washed occasionally. An ointment composed of castor-oil, alcohol, and a small quantity of oil of rosemary, is a valuable remedy in case of dandruff: it should be well rubbed into the scalp.

28. *Hair-dyes* which are represented as containing no poisonous mineral matter, often depend upon salts of lead or nitrate of silver for their efficiency in dyeing. These

¹ Indigestion from overeating, highly-seasoned food, and excess in drink, often cause eruptions of the skin.

harmful minerals are absorbed through the skin when frequently applied to the hair of the head or to the whiskers, and they sometimes produce dangerous or even fatal results. Cases of paralysis apparently due to the use of hair-dye have been reported; and it is said that Bright's disease of the kidneys may occasionally owe its origin to a long-continued use of skin-powders and hair-dyes.

29. Alcohol and the Skin. — Bodily Temperature, etc. — The primary effect of a considerable quantity of alcohol taken into the system is a *paralysis of nerve extremities*, and for a time it suspends the power to feel. The sense of touch, also, frequently becomes much less delicate in habitual drinkers.

30. The nerves of the small blood-vessels of the skin becoming paralyzed, these little tubes relax and become over-crowded with blood, as is shown by the flushed face, hands, and skin generally. The temperature of the surface is at first increased; but the flow of a greater quantity of perspiration and its rapid evaporation, together with the enlarged radiating surface of the blood-vessels, soon aid to lower the temperature much below the standard of health. Hence, alcohol is, in the end, a *reducer instead of a producer of warmth*, and the power of resistance to cold is weakened by its action. It is especially dangerous to persons who drink it when they are to be exposed to a low temperature.¹

Sometimes the over-filled condition of the capillaries of the skin becomes permanent and is manifested in the red, blotched face and nose of the "heavy drinker," a condi-

¹ It is the testimony of all Arctic explorers that men who do not use alcohol endure exposure to severe cold much better than those who drink it; in fact, it has been found necessary to avoid its use when about to be exposed to severe cold for a considerable time.

tion so remarkable as to amount to disfigurement of the skin.

31. Tobacco and the Skin. — Through its effects on the system in general, the excessive use of tobacco interferes with the health of the skin. It is not unusual to find the skin of inveterate smokers either pale or of a yellowish, smoky cast. When a boy "takes to smoking," his skin is apt to become pale and unhealthy.

32. Chronic Diseases of the Skin. — In concluding a treatise upon the skin in health and disease, Dr. L. B. Bulkley says: "In chronic skin diseases the whole system is chronically deranged; and to accomplish their cure, and to prevent their return, it is frequently necessary to alter the condition of the system. To accomplish this, we cannot simply apply a wash or a salve, or take a few drops of this or that remedy, but must by a combination of all the means known to science, by diet, hygiene, and medicine, restore the disordered organ and system to the state of health. And the application of the same rules, together with self-restraint, will serve to prevent a recurrence of the skin disease."¹

CHAPTER XXXI.

CLOTHING.

1. Object of Clothing. — From moral and ornamental standpoints, clothing generally receives much attention and consideration; but its main purpose, the preservation of health, is too frequently ignored. It will be recollected

¹ *The Skin in Health and Disease* (HEALTH MANUALS, vol. iii.), by L. DUNCAN BULKLEY, M.D., *Attending Physician for Skin Diseases, etc., at the N. Y. Hospital.*

that external portions of the body are from one to two degrees cooler than internal parts, and that radiation and evaporation from the surface constantly tend to increase this difference. Any considerable deviation from the normal standard of temperature in the body results in disturbance of the work of organs, and consequently in injury to health. Now, the chief purpose of clothing is *to maintain the proper balance between the inner and the outer temperature of the body*. Clothing does not create heat: it simply preserves it, regulates its radiation from the surface, and guards the body against sudden changes of its temperature.

2. Clothing, by preserving the warmth of the body, is an economizer of food and of muscular and nervous force. It enables food to apply itself to the building up and repairing of the tissues, instead of being used up as fuel merely to compensate for a constant waste of heat. We cannot afford to overtax the body in making an undue amount of heat, nor can we afford to lose warmth faster than the body can properly make it; and clothing saves the system extra labor by retaining its heat. Liebig, the eminent chemist, remarks that, "our clothing in reference to temperature is merely an equivalent for a certain amount of food." Animals, unsheltered and exposed to the cold, lose fat and muscle; but when properly sheltered, they increase in these upon a smaller allowance of food. It is well known that human beings require less food, and are capable of more work, when comfortably clothed and warm than when too thinly clad and chilly.

3. In order, then, that clothing shall fulfil its main purpose, we must give the most *careful consideration to "what we wear, and to how and when we wear it."*

4. **Essentials in Clothing Material.** — Heat is conducted through some materials much more freely than through others. By interposing a *non-conducting* material between the surface of the body and the external air, we prevent the loss of heat which would otherwise result. Again, as a non-conducting substance prevents the escape of heat from within, it is equally effective in retarding the entrance of heat from without. This is proved by ice being preserved from melting when wrapped in flannel or other woollen fabric, which retards for a long time the approach of heat to it.

5. Men exposed to the intense heat of furnaces and steam-boilers almost invariably protect themselves with non-conducting, woollen garments. "The thick cloak which guards the Spaniard against the cold of winter is also, in summer, used by him as a protection against the direct rays of the sun." Hence, clothing should be of a material and texture which will serve this double purpose.

6. In every case, it is the property which clothing material possesses of detaining air in its meshes, and allowing it to be exchanged slowly, that constitutes its value. A fabric while not being so loose in texture as to allow currents of air to pass directly through it, should be so porous as to permit a constant but gradual change of the air in contact with the skin, and thus transmit the insensible perspiration without obstruction. "In one sense, perhaps, clothing is objectionable. It cannot be denied that if the skin could bear changes of temperature without danger to the system at large, the contact of fresh air would make it more healthful and increase its power of resistance."

7. Materials for clothing differ widely as conductors of

heat and in other properties which also render them more or less valuable as coverings for the body.

8. Properties of Woollen Clothing.—Wool, when manufactured into a soft fabric of porous texture, is an excellent non-conductor of heat and retainer of moisture, whether from within or from without. It is a much better protection against cold than cotton or linen of equal thickness.¹ When, however, wool is spun into a hard, worsted thread, and woven into a firm, compact cloth, it becomes a better conductor of heat, and is then not so well adapted for protection against cold. Fine wool, woven into loose, soft fabrics, is superior to all other materials, fur excepted, as a protector of the body against sudden changes of temperature. Flannel underclothing, *varying in thickness with the different seasons*² of our variable climate, should be worn next the body, summer and winter. Sometimes flannel irritates very delicate skins; but this difficulty may be overcome easily by wearing it outside of muslin or linen, or, better still, by lining the flannel with silk. However, flannel in most instances soon ceases to irritate the skin, and becomes simply a means of keeping the surface stimulated. Even while perspiring, one may go into the open air of winter with much security, if clad in flannel.

The outer clothing may be quite safely left to be decided by the comfort and taste of each person. As

¹ A tin vessel of hot water and covered with woollen cloth takes longer to cool than a similar vessel does when enveloped in cotton or linen fabric of equal thickness. Ice cannot be preserved more effectually in summer than by wrapping it in flannel.

² Thus Providence clothes the animals of cold climates with a shaggy covering from which those of the tropics are free. The coats of many animals in temperate regions change with the seasons, being close and longer in winter, thinner and shorter in summer. While we differ from the lower animals in habits, conditions, and surroundings, we may yet draw useful inferences from their economy.

warmth, however, depends more upon the material than upon the quantity of the clothing, woollen outer clothing is superior to the other kinds; and less of it is needed when the body is properly supplied with underclothing.

9. **Silk, Cotton, and Linen as Clothing.**—*Silk* is a better conductor of heat than wool, but a poorer conductor than cotton. Its fibres are round and pliable, and it makes an agreeable garment for the skin. It ranks next to wool in suitableness for underclothing. It does not readily absorb moisture, and it gives a sensation of freshness to the skin. Like other material, its fitness for underwear is lessened when its threads are hard-twisted and woven into a compact fabric, for it then conducts heat more rapidly.

10. *Cotton* is a better conductor of heat than wool or silk, but a poorer conductor than linen. It absorbs moisture less freely than linen does. When spun with a slack twist and woven loosely, it becomes a good non-conductor. Thus cotton flannels with a downy nap approach wool quite closely in suitableness for underwear, but are rather too heavy and become saturated with moisture; but closely-woven muslin shirtings are but little better than linen in this respect, and are not fit to be worn next the skin. In the scale of values, cotton as clothing is intermediate between that of wool and silk.

11. *Linen* conducts heat and absorbs moisture very rapidly, and is therefore the poorest material for underwear. Retaining moisture which it absorbs, and parting rapidly with its warmth, it feels cold to the touch. Those who wear it next the skin are chilled after sweating, even in a hot day. It should not be worn next to the skin, except when covered by flannel, as before mentioned. Linen fabrics of light color are, however, good reflectors of the

direct heat of the sun, and serve a good purpose as outer garments in summer.

It should be understood from what has been said, that while materials differ greatly in their conducting properties, the chief difference in the fabrics used for clothing lies in their porous texture, or in the amount of air contained in their meshes.

12. India Rubber, and "Water-proof" Clothing. — The non-porous nature of India-rubber and other "waterproof" garments makes them very useful as a protection against rain and cold winds; but they should be worn only when necessary to accomplish this purpose, and never longer than is required to do so. These impervious fabrics excite very free perspiration, and at the same time prevent its evaporation, causing chill and liability to take cold after the garment is laid off. So far from healthful are rubber over-garments that their use has been forbidden in the French army. Undoubtedly the "abuse of the use" of such garments led to this prohibition. Rubber overshoes are, for similar reasons, injurious when worn for a length of time; they prevent all evaporation, and thus make the feet and stockings damp. "Arctics" made of lighter "water-proof" material are much less injurious, but even they should be worn as short a time as may be.

13. Influence of Color in Clothing. — The color of *outer* clothing is more than a mere matter of taste and ornamentation. It is a well-known fact that snow when covered with black cloth melts sooner under the rays of the sun than when covered with a white cloth and similarly exposed. It has been ascertained by experiments made with shirtings of the same material exposed to the sun, that white received 100° Fah., pale straw color 102°, dark

yellow 140,° light green 155,° dark green 168,° light blue 198,° and black 208,° the warmth of the fabric increasing with the depth of color. Hence, the color of clothing is of importance in a physiological sense. In tropical regions and during our warm summers, clothing is required largely as a protection against heat of the sun; and *a principal consideration is color*, the best being white, and thence downward in the scale of value to black, which is the poorest. When not exposed to the sun, the influence of color in clothing is not marked.

14. Common Errors in Dress.—*Winter underclothing should be put on early and taken off late.* It is much better to make a change of *outer* garments if a day be warm, or to increase the amount if the weather become suddenly colder. The great physician, Boerhaave, said, "Flannel should not be put off till midsummer's day, and should be put on—the day after. Only fools and beggars suffer from cold; the latter not being able to get sufficient clothes, the other not having the sense to wear them." It is an error to make a sudden decrease in the amount of underclothing.

15. The habit of clothing the upper portions of the body warmly while the legs and feet are neglected is injurious. The clothing, especially in winter, should protect all parts so as to equalize warmth. Clothing the lower portions of the body too scantily results in driving the blood away to the upper portions, which then have too much of it and become over-sensitive.

16. Swaddling the throat and lower portions of the face with thick coverings in cold weather is generally an error. A thick veil worn over the face for a length of time deprives the lungs and blood of much of the oxygen which

is food and life to them. Once begun, these practices must be continued, because the parts mentioned become over-sensitive to cold. Still, there is an exception to this rule. After speaking or singing for a length of time, it is unsafe to expose the throat to cold air or to breathe it ; the throat and vocal organs, being very warm from exercise, would be easily chilled. Protection should be had in this case, "not by wrapping a heavy scarf, or by buttoning a fur collar about the throat and mouth," but by enveloping the throat and lower part of the face in a large handkerchief, preferably one of silk, loosely cast about them. The breath, being directed against the covering, warms the air to be inhaled ; the mouth should be kept closed and breathing be carried on through the nose. It is a serious error to allow wrappings to remain about the throat long after entering a warm room ; this causes chilling on going out of doors.

17. *The wearing of overcoats, cloaks, or other heavy street-garments, while in warm rooms, as in churches, theatres, etc., is a foolish and dangerous error.* This practice, very common in our country, causes the blood-vessels of the skin to dilate, the perspiration to flow freely and to saturate both the under and intermediate clothing ; and in this condition of dampness, the wearer goes out to encounter the cold air. Such carelessness arises often from indolence, and is almost, sometimes quite, suicidal. Another error akin to the foregoing is the habit of removing outer garments in cold weather immediately on entering a house, or of passing out into the cold air at once after putting them on. This practice is a frequent cause of colds.

18. *It is an error and dangerous to believe that scanty*

clothing will "harden" or inure the body to cold and sudden changes of temperature without producing injurious effects. In the Highlands of Scotland, where the kilt, or short petticoat, scarcely meets the stockings of the wearer, rheumatism of the knees is quite common. The natives of Tierra del Fuego wear little or no clothing even in the coldest weather, but are dwarfed, hideous beings; and the cattle of cold regions are small and stunted. Cold arrests development — "cold is death, heat is life."

19. *On the other hand, we may make ourselves tender by wearing too warm clothing.* Those who always clothe heavily retain, in part, a "summer constitution," and cannot bear what others do when cold weather comes, or when the temperature falls suddenly. No exact rule can be given for the amount of clothing, other than that it should be regulated to suit our habits, health, and exposure, and be just sufficient to keep the body comfortably warm. By carefully adapting it to the coldness or warmth of the weather, we avoid necessity for hardening, and are less liable to become tender.

20. *Tight-fitting clothing does not protect against cold as well as looser clothing does.* Moderately loose garments allow a small space between them and the body, and the layer of warm air in this space preserves the warmth of the body. Loose gloves, for instance, protect the hands against cold much better than tight ones do. Clothing, night-garments especially, should not fit so tightly about the neck as to obstruct the circulation by pressure upon blood-vessels. Tight-fitting, uncomfortable clothing is, more frequently than we are aware of the fact, a source of irritability and bad temper.

21. *Tight-fitting, heavy hats interfere with the circulation*

in the scalp, and, by pressure upon blood-vessels and nerves, cause headache. Hats should be tolerably light in texture, or have means of ventilation in order to prevent overheating the scalp and inducing baldness.

22. *Tight-fitting boots and shoes, especially when they have narrow soles and high heels*, by pressure upon the skin and joints, cause corns and bunions. When too loose and ill-fitting, they chafe projecting portions of the feet, and sometimes cause troublesome sores.

23. *An excess of bed-clothing is as harmful as too little of it*. It is natural to wish to become speedily warm after going to bed on a cold night; and hence the temptation to use too many blankets, etc. At first the warmth is agreeable and not injurious; but later, after one has been lulled to sleep, the excessive amount of clothing induces more or less profuse perspiration, while preventing its evaporation. The sleeper awakens unrefreshed and weakened, and is consequently very liable to take cold.

24. **Cleanliness and Care of Clothing.** — *All clothing should be kept clean*. Underclothing, especially, absorbs perspiration and becomes charged with waste particles and the *débris* of the epidermis. Some of the poisonous products of this decaying matter may be absorbed through the skin and re-enter the blood, or at least by filling the meshes of the clothing prevent evaporation from the skin. A neglect to change clothing frequently is not only a filthy habit, but is a source of disease. Woollen clothing, in particular, when not purified by thorough ventilation and disinfection, has been known to convey the contagion of scarlet fever even three years after it was impregnated with the spores of the disease.¹

¹ See directions for disinfection of clothing, etc., in Appendix. Clothing in its relation to the framework, circulation of the blood, muscles, etc., is mentioned under the appropriate topics of our subject.

25. *There should be an entire change of clothing on going to bed.* The underclothing worn during the day should be aired and dried, and should be well shaken before being put on again.

26. *Night-clothing and the blankets and beds should be thoroughly aired every day,* and refuse particles should be shaken out of them. Night-clothing not less than day-clothing becomes charged with impurities, and may become a source of disease. It is an error to "make up" beds soon after they have been occupied, thus shutting in the moisture and impurities that have been absorbed from the body.

27. *Wet clothing should be removed from the body at once.* Indolent carelessness in not removing damp garments, shoes, and stockings immediately after entering the house frequently occasions the infliction of a severe penalty. A delay of five minutes may be sufficient to permit the congestion of an internal organ, for instance the lungs or the bowels, and lead to serious or fatal illness. Dry, well-warmed clothing should replace the wet, and the feet should be thoroughly rubbed and dried. In inclement weather young people are apt to enter the schoolroom or their homes in damp garments and with wet feet, and to remain in this condition for a length of time. This should never escape the notice of teachers and parents. At school the pupil should be required to dry his garments and feet, or should be sent home to do so. Wet garments abstract heat very rapidly from the body.

28. *When wet clothing cannot be changed at once, the person should not sit still and shiver,* but should exercise moderately, and in this way keep up the warmth of the body. It is well, too, to recollect the sailor's trick when wet

clothing cannot be changed for dry — take off the wet garment, wring the water out of it, and put it on again ; it will be found to be much warmer.

29. Poisonous Clothing. — The poisonous effects of cheap dyes, containing arsenic, copper, etc., in cheap, bright-colored clothing, should be known. Cases continually come to the notice of physicians in which colored gloves, stockings, tights, undershirts, hat-linings, etc., have been found to be poisonous, to cause eruptions, and to lead to eczema or other disease of the skin. Recently a Foulard cambric garment had been worn by a lady only a short time when she became seriously ill. There were found to be $3\frac{1}{2}$ grains of arsenic in one square yard of the cloth.

Suggested Points for Questions.

CHAPTER XXVII. — 1-4. Importance of the skin — protection, excretion, regulating of bodily temperature. Depression and imperfect work of skin. Melancholia — skin dense and inactive, cold and dampness as related to the skin, importance of securing free action of skin — clothing, bathing, friction, exercise. Parts of the skin harmoniously united, wear and renewal, elastic and resistant properties; functions mentioned in general; result of obstruction. 5, 6. Layers of the skin — number, names, difference, adherence, relation to underlying tissue; looseness in certain regions, suppleness desirable — instances. Modified skin — mucous membrane, nature of and location in general. 7-9. The derma — general character, fibrous structure, leather from derma. Connective tissue — fat deposit, etc.; papillæ — appearance, disposition, arrangement, where numerous; epidermis dips between papillæ. Organs of the derma — nerves, blood-vessels, glands, etc. 10-14. The epidermis — appearance, location, structure, office; unlike the derma — no fibres, but cells, varying thickness — why? Three layers of epidermis — horny, *rete Malpighii*, and pigmentary — location, appearance, structure, changes, etc., of each; varying color of the skin; epidermis removed — red appearance, and modifications, cause of; discolored marks on skin, — causes (note).

Epidermis bloodless, nourishment of; blisters, scars from injuries — when. 15. Muscles of the skin — amount, location, office in the lower animals and in the human.

CHAP. XXVIII. — 1, 2. Vessels, nerves, and glands — object and responsibility of, in the skin; when their labor ceases. Vessels, etc., named. 3. Capillaries — abundant supply proven; capillaries in relation to papillæ — course to veins. 4, 5. Nerves of skin — number, peculiarities of classes; tactile corpuscles — structure, location, number in different parts, function. Object of abundant nerve supply of skin — the skin and pain. 6-9. Sebaceous glands — description of as to location, size, kind of secretion. Connection with the hair-pits and emergence to surface — number. Quantity of sebaceous matter and function. Glands inactive — result; obstructed — “skin-worms,” pimples. Surplus sebaceous matter — removal; effects of neglect to remove — clogging, disease. 10-12. Sweat glands — location, structure, duct and opening; course through derma and epidermis — difference. Arrangement of openings on skin. Tube — diameter, length, total number, united length. Varying number in different parts; process of secretion of perspiration, from blood — capillary surroundings of glands; constituents of perspiration. 13, 14. Forms and quantity of perspiration — constant secretion; sensible and insensible perspiration described. Quantity of perspiration — comparative and daily; amount varying — causes; excessive perspiration and thirst — cause. 15. Absorption by the skin — function and where most active; medicines administered, thirst relieved, nourishment supplied — absorbed. 16. Breathing through the skin — experiment demonstrating the fact; condition of air enclosed around a body — gases interchanged. 17, 18. Functions of skin, lungs, and kidneys compared — similarity and in what respects; functions of skin and kidneys most alike; action of each in hot and in cold weather. Result of interruption of action of one set of organs — endeavor to compensate and how far possible; a varnish-covered skin — result; burned or scalded skin — result; importance of care of skin.

CHAP. XXIX. — 1, 2. Perspiration and heat — regulative agency of perspiration; uniform temperature maintained; average normal temperature of surface (note). Action of vaso-motor nerves when blood becomes heated — expansion of capillaries and increased secretion of perspiration; process of abstracting heat. 3-5. Perspiration and cold — contraction of blood-vessels and result; diminished perspiration — cause; radiation lessened. Sudden lowering of bodily temperature — effect of blood being driven to internal organs and weak spots. Fatal lowering. 6. Perspiration and dry air — rapid evaporation — cause; possibility of remaining in an oven when perspiring freely — instances and philosophy of; effect on temperature of blood. 7.

Perspiration and moist air — physical discomfort and cause; slow evaporation of perspiration; 80° in damp air *versus* 90° in dry; workmen at furnaces and high, moist temperatures; “heat-stroke” and high temperature of moist air — bodily temperature then fatal. 8-10. The hair — appendage of epidermis; structure of hair — root, shaft, follicle, hair papillæ, blood-vessels, nutrition; effect of destroying papillæ. Canal of hair, cells and coloring matter. Diameter of hair, abundance, estimated number on head, enduring nature (note). Functions of hair. 11-13. The nails — composition, location on matrix, mode of growth — cell deposit, thinner at root — cause. Result of injury to matrix; injury at root; skin diseases affect nails; sickness affecting nail growth; nail disease, and effect of age. Functions of the nails; “club-ended” fingers — cause.

CHAP. XXX. — 1. Hygiene of the skin — chief considerations — cleansing and regulating temperature of. 2-5. Cleansing necessary — matter deposited on the skin; sedentary life in warm rooms — deposits on skin. Poisonous matter absorbed by the skin — painters, etc. Impurity of blood from inactivity of skin — depression, headache. Health and a clean skin. 6-13. A warm bath for cleanliness — temperature and avoidance of shock and excessive stimulation; difference between warm and hot. Remaining too long in bath — proper time. Skin dried by friction — why and how. Frequency of warm bath — varying with condition; winter and summer frequency — gradual increase. Best time for warm bath — reason. Bathing immediately after a meal — why improper. Use of soap in bathing — why; kinds and effects. 14. Hot baths — special benefits to be derived from; duration and method of taking — skin drying; promptly to bed; hot bath, etc., in breaking up a cold; frequent hot bathing improper — why. 15. Cold baths — first effects, shock, contraction of blood-vessels of skin, stimulated action of heart and lungs, reaction and warmth; bath end while glow continues — reason; friction beneficial. Tardy reaction injurious — congestion of internal organs — conclusion drawn. 17-19. Sea bathing — stimulating effect; benefit in weakness from rapid growth; caution required by the extremely nervous and in heart disease; medical advice as to bath by invalids. Manner of taking sea bath; comfortably warm on entering, activity while in — reason; shock and reaction followed by chilliness — danger signal; when bath should end; a cold, “still-bath,” warm, salt-bath — for the weak. Frequency, time when, drying and friction. Care in diet at seashore. 20-23. Friction baths — body reacts slowly from cold in morning — reason; morning not best time for full bath. Wet friction bath in morning beneficial; method and appliances. Dry friction bath — method of taking; preparation of mittens for. Benefits of friction bath. 24-26. Washing of face and hands, cos-

metics—effects of strong soap; use of soap—frequency; drying important—reason. Poisonous cosmetics—nature and effects; use of harmless face-powder; benefits of moderate friction; the most effective beautifiers. 27, 28. Care of scalp—importance of cleanliness; sources of refuse matter; unhealthy secretion—obstruction of pores. Brushing and brush; fine comb objectionable; washing of scalp; a valuable ointment and use of. Hair-dies—nature of, danger of use. 29, 30. Alcohol and the skin—paralysis of nerves; blunted sense of feeling and touch. Relaxed blood-vessels—flush; effects on temperature of skin—reaction and chill; reducer of warmth—danger in low temperatures; permanent congestion of capillaries—indication. 31. Tobacco—effects extending to the skin; pale, yellowish skin; skin of young smoker. 32. Diseases of the skin—whole system involved; diet, hygiene, and medicine necessary.

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THE SPECIAL SENSES.

CHAPTER XXXII.

SIGHT.

1. **Sensation in General.** — Our knowledge of the existence and conditions of the various parts of the body, and of objects in the external world, is based upon *sensations* through the nervous system as a medium.

2. Many sensations are common to all portions of the body, and are not distinctly confined to a single organ or region at all times. Among these common or *general sensations* may be mentioned pain, fatigue, restlessness, hunger, faintness, etc. However real these sensations may be, they tell us nothing of objects external to the body.

3. One of the common sensations is that peculiar one termed the *muscular sense*. The object of this sensation is to give a knowledge of the exact condition of the voluntary muscles. By it the mind knows precisely the degree of contraction of any of these muscles, and the degree of resistance which arises when any obstacle is opposed to the movement of the body or any part of it. Thus when an arm is lying by the side, the mind is conscious of its position; and when the arm is raised a shorter or a greater distance, a feeling of *resistance to effort* occurs. It is this

consciousness of the position of muscles and parts to which they belong, and of their exertion, which is named "the muscular sense." Except during the unconsciousness of sleep, we are at all times cognizant of the position of the body and its limbs by means of the sense of contraction or relaxation of the muscles.

4. Special Sensations. — A number of sensations arise from impressions made upon definite parts of the body. Each of these sensations is produced by a stimulus applied to that part of the body, and cannot be produced when applied to other parts ; in other words, the impressions are received by specially constructed organs of sense, so that they are distinctly local in character. Thus the sensations of taste and smell are confined to certain portions of the mucous membrane of the mouth and nose ; those of sight and hearing to the eye and ear ; and those of touch are restricted to the skin and to certain membranes lining the internal cavities. Any portion of the body to which a sensation is thus specially restricted is called a *sense organ*, and the sensations are called *special senses*. All the special sensations are referred to external objects or causes.

The special senses are *sight, hearing, touch, taste, and smell*.

5. The Sense of Sight. — First in importance among the special senses is that of sight. Through it are received the most varied and valuable impressions, and by it we become cognizant of objects around us, and are enabled to appreciate the beauties of form and color in nature. Deprived of it we should lose so much that is grand and beautiful in life, that to behold a blind person fills us with pity, while the thought of such an affliction falling upon

ourselves appalls the bravest mind. Sight and touch are very intimately related in some of their functions.

6. Anatomy of the Eye.— Securely lodged in the cavity or socket prepared for it in the front part of the cranium, is that organ, marvellous in structure, which enables us to see. The *eyeball* is nearly spherical in form, and is protected by the bony socket in which it is set, and by the curtains of cartilage and skin, the *eyelids*. To still further ward off insects, and veil it from dust or particles that might invade it, the *eyelashes* close and interlock when the

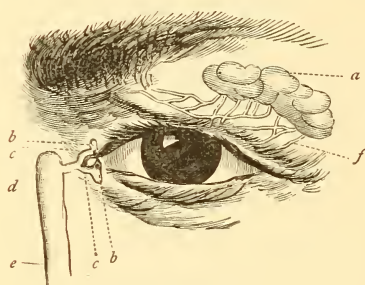


Fig. 53.

EXPLANATION.

a, the *lacrimal*, or *tear-gland*, lying beneath the *upper eyelid*.

b, b, the situation of the openings through which the tears flow into the *tubes* that convey them into the *nasal sac and duct*.

c, c, the *tubes* continued from the openings.

d, the *nasal sac*.

e, the *nasal duct*, continued from the *nasal sac*.

f, little canals that convey the tears to the *eye* from the *gland*.

lids are brought together, while the *eyebrows* surmount all and aid in preventing perspiration from running into the eyes. To lubricate its surface and prevent friction against the lids, there is a watery secretion from the *tear-gland*. The eye is supplied with nerves and blood-vessels, and its freedom of motion in various directions is due to the action of muscles attached to its outer coat.

7. The muscles of the eye are represented in Fig. 54. The natural appearance of the eye and accurate sight depend largely upon the harmonious action of the muscles which move the eyeball. When one muscle contracts

unduly, the eye is drawn out of the line of direct vision ; so also when a muscle is weakened and relaxed, the same

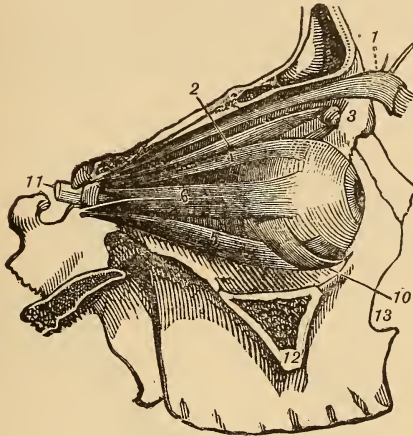


Fig. 54.

EXPLANATION.

To the outer surface of the *sclerotic coat* are attached six muscles. Four of these are called *straight muscles*, two of which roll the eye upward and downward : the other two give it a sidewise motion to the right and left. The remaining two are called *oblique muscles*, and serve to roll the eye inward and downward.

1, the muscle which raises the *upper lid*.
 2, the *superior oblique muscle*.
 3, the pulley through which its *tendon* plays.
 4, 5, 6, *straight muscles*.

10, *inferior oblique muscle*.
 11, the *optic nerve* (nerve of sight).
 12, cut surface of *cheek-bone*.
 13, opening of the nose or *nasal orifice*.

condition is produced, in either instance causing *strabismus*, or *cross-eye*.

8. The eyeball is about an inch in diameter, and, though apparently spherical, is really a little elongated from before backward. It is composed of three *tunics*, or coats,

enclosing three refracting mediums, all being so arranged as to constitute a complex optical instrument.

9. Coats, Humors, Lens, etc., of the Eye. — The outer layer of the eyeball, the *sclerotic coat* (Gr. *skleros*, hard) which forms the posterior five-sixths of the ball, is a white, hard, fibrous structure continued in front by the *cornea*,

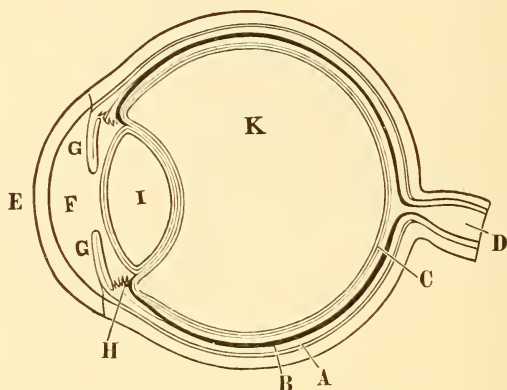


Fig. 55. — Diagram of Vertical Section of the Eye.

EXPLANATION.

A, The Sclerotic Coat.
B, The Choroid Coat.
C, The Retina.
D, The Optic Nerve.
E, The Cornea.

F, The Aqueous Humor.
G, The Iris.
H, The Ciliary Processes.
I, The Crystalline Lens.
K, The Vitreous Humor.

(Lat. *cornu*, horn) or transparent sixth, through which light passes to the interior of the globe. The part called the *sclerotic coat* maintains the shape of the eyeball, and, by its elasticity, controls the proper curvature of the cornea. It also affords attachment to the muscles that move the eye, and protects the more delicate parts within. The cornea forms the prominent curved surface of the

front of the eyeball, and is the window of the eye, being as essential to sight as a window of a house is for the admission of light. It is not supplied with blood-vessels, but receives its nutrition by diffusion from other parts.

10. The second layer is called the *choroid coat* (Gr. *chorion*, leather), and includes the *iris* (Lat. a rainbow), the curtain-like portion immediately back of the cornea. The choroid coat is a thin membrane containing a large number of minute blood-vessels, and is rendered opaque by a layer of dark-brown matter, called pigment-cells. One use of this coat is to darken the interior of the eye by absorbing all extra light, and thus prevent dazzling reflection that would confuse the sight.

11. The *iris* is the thin, contractile, circular portion of the choroid coat situated between the cornea and the lens. It is perforated in the centre by a circular aperture, the *pupil* (Lat. *pupilla*, puppet), for the admission of light. It is supplied with muscular fibres, some of which are arranged as a ring around the pupil, while the others radiate from it. The office of these little muscles is to regulate the quantity of light admitted into the eye; thus the pupil contracts to exclude some of the light when too much is entering the eye, and dilates to admit more rays when the entering light is not sufficient to produce distinct vision. The curtain-like iris is lined behind by a dark substance, the thickness of which determines the color of the eyes of different individuals.

12. The third coat of the eye, called the *retina* (Lat. *rete*, a net), is the delicate nervous membrane which lies within the choroid coat and forms the innermost layer of the eyeball. It consists of an expansion of the fibres of the nerve of sight, supported by an extremely delicate

connective tissue. It is this nerve-membrane that receives the images and transmits the impressions along the optic nerve to the brain, to produce the sensation of sight.

13. The *crystalline lens* is a double, convex, transparent, solid body, close behind the iris. Its front surface, which is less convex than the back, is in contact with the iris, and a space is enclosed between these structures and the cornea in front. The lens is about one-third of an inch in diameter, is enclosed in a delicate membrane called its *capsule*, and has attached to it a strong, elastic frame, called the *suspensory ligament*, which is connected with the choroid coat. By the action of certain muscles and of this ligament the lens is made to change its shape (become more or less convex) and its position, so as to rapidly adapt the apparatus to long or to short ranges of vision. The office of the lens is to converge the rays of light to a focus on the retina, in order to produce a perfect picture of the objects around us.

14. The cavities or spaces within the globe of the eye are occupied by the *aqueous* and the *vitreous* humors. The *aqueous humor* (Lat. *aqua*, water) is a clear, watery fluid which fills the space between the cornea in front and the iris and lens behind; and the *vitreous humor* (Lat. *vitreus*, glassy) is the transparent, rounded, semi-solid substance which fills the entire space behind the lens. The former of these humors (the aqueous) keeps the cornea in natural condition, and assists in maintaining its convexity; the latter (the vitreous humor) acts in slightly diverging the rays of light after they pass through the lens.

15. **Appendages of the Eye.** — Among the appendages of

the eye which demand special mention on account of the importance of their functions are the eyelids, the tear-gland, and the ducts related to it. Certain general functions of the eyelids, eyelashes, and eyebrows have already been stated.

16. A thin mucous membrane, called the *conjunctiva*, lines the inner surface of the lids and the outer surface of the cornea and front part of the sclerotic coat. The part of this membrane that lines the lids contains many blood-vessels, and is very liable to inflammation. A number of small glands are situated in this membrane, and from these a number of small canals or ducts open on the edges of the lids and pour out a secretion to oil the lashes and prevent the lids from adhering together.

17. The *lachrymal gland* (Lat. *lachryma*, a tear) is situated in a depression of the bone in the upper and outer portion of the orbit of the eye. It is about the size of an almond kernel, and secretes the tears, which are conveyed by several little ducts to the upper surface of the eyeball. Every motion of the eyelids assists in distributing the fluid over the surface of the eye till it reaches the inner corner of the eye, where it enters the mouths of two small *lachrymal ducts*, and is conveyed by them into the *nasal duct* and by it into the nose, having carried with it any particles of dust which may have adhered to the surface of the eye. If these ducts are obstructed in any way, the tears must flow out and over the cheek; and when an excessive amount of fluid is secreted, as in crying or through irritation of the eye, the surplus must flow over the lower lid because all cannot be conveyed by the canal leading into the nose.

18. **The Phenomena of Sight.** — Perfect sight is the result

of a combination of various agents. In the first place there must be light. A body giving forth light sets waves in motion in that *ether* which surrounds us, in the same way that a stone thrown into the water propagates waves which expend themselves on the farther shore. Variations in the length of these waves produce varieties in the color of light, and also differences in its intensity. When a ray of light (or these vibratory waves) falls upon the eye, several phenomena occur, and the impression thus made is called a *visual sensation*, and is purely physical. Our recognition of the object is called a *visual judgment*, and is purely mental.

19. The sensation caused by light continues longer than its presence. If two lightning flashes occur very nearly together they appear as one, the sensation caused by the first continues and is blended with that of the second. A lighted stick moved rapidly in a circle will, for like reason, present the appearance of a circle of fire.

20. The degree of intensity of light depends upon the brightness of the object emitting it; but there is a point reached at which an object appears no brighter, however much its inherent brightness may be increased. Thus the eye allows only a certain degree of stimulus, and beyond the point where danger to its function might be induced, it refuses to recognize increased brilliancy.

21. "Among the phenomena, all of which constitute *sight*, some belong to the domain of physics, and may be submitted to investigation; many may even be demonstrated by experiment; while others, on the contrary, are patent to the observation but little known as to their cause or mechanism."

22. **Visual Sensation, or How We See.** — The phenomena

that occur in the eye in receiving the impression produced by light are as follows: Rays of light from an object pass through the transparent cornea and the pupil to the lens, which, like the lens of a camera, converges the rays and refracts them to a point on the retina, and this point is called the *focus*. In passing through the lens, the rays converge and then cross, and an inverted image of the object is produced upon the retina, just as the image is placed upon the screen of the photographer's camera. The impression made upon the nervous retina is communicated to the *optic nerve*, and by it to the brain, where it is recognized and becomes a *visual sensation*, or *sight*.

23. The pupil has the power of contraction to enable it to adapt itself more completely to the amount of light, and to limit divergent rays. This is the first act of *accommodation*. In the second place, the lens can change its shape slightly so as to become more convex, and thus change its *focal distance*. This is the second act of accommodation. By these two means the eye accommodates itself to rays coming from a far or a near object. These movements of accommodation are rapid and not under the control of the will, but are responses to the stimulus of light. Certain poisons acting on the nervous system also cause contraction of the pupil. The opposite state, dilation, is produced by absence of light, by violent muscular efforts, and by the effects of certain other poisons on the general system.

24. The retina is not equally sensitive in all its parts to light. A point in the retina very nearly opposite the centre of the pupil is much the most sensitive. A slight depression in the surface, marked by a pale yellowish color,

indicates this point, and it is called the *yellow spot*. In looking at an object, that part of it which is in a straight line with the yellow spot and the centre of the pupil is most distinctly defined in the retinal image,—in other words, it is most clearly seen. This accounts for the fact that the eyeball naturally turns so as to bring the object, the centre of the pupil, and the yellow spot into this line, the *axis of vision*.

25. On the other hand, that point in the retina where the optic nerve enters the back of the eyeball is insensible to light, and is known as the *blind spot*. A very simple experiment will furnish proof of this: On the page below we have placed a cross on the left side and a large dot on the right. Close the left eye, and look steadily with the right at the cross, holding the page at a distance of ten or twelve inches.



Both dot and cross are thus seen quite distinctly. Now, move the book very slowly toward the eye, keeping it still fixed upon the cross. At a certain distance—generally about six inches—the dot at the right will suddenly disappear, owing to its image falling on the blind spot; but on bringing the page still nearer the eye, the image of the dot leaves the blind spot, and is again perceived.

26. The *sensibility of the retina* is readily exhausted by excessive light. In looking at a very bright light for a time, that portion of the retina on which the light falls soon becomes insensible, so that in turning from the light and looking at a white surface a dark spot appears.

The rays of light from this surface fall upon the exhausted point in the retina, and produce the appearance of a dark spot, precisely as in the absence of rays.

27. **Normal-Sight, Near-Sight, and Far-Sight.** — Ordinarily, or in *normal sight*, the eye can adjust itself to see distinctly objects that are brought as near as five or six inches; but when objects are brought still nearer, sight becomes blurred and indistinct. Again, it can also adjust itself for objects at a very great distance, any indistinctness of the images produced on the retina being due to their minuteness, but not to any want of proper focusing of the eye. The range of sight of the normal eye, when we read or write, is about fourteen inches. Some people, however, are born with, or afterward come to possess, eyes in which the limit of distinct sight is much closer, sometimes as near to the cornea as one or two inches, and such eyes are said to be *near-sighted*.¹

28. In near-sightedness the cause is not always the same; but in the majority of cases the condition results from a too great convexity of the cornea and lens, or from an elongation of the eyeball from front to back, thus making the distance between the lens and the retina too great. In either case the rays of light come to a focus before reaching the retina (somewhere in the vitreous humor), and consequently no image of a distant object is produced on the retina. To remedy this difficulty, *concave* glasses, which properly diverge the rays and thus prevent the focus before reaching the retina, should be worn by near-sighted people.

29. On the other hand, there are many people who cannot see near objects distinctly, while distant ones are

¹ *Myopia*, or short sight.

clearly seen. Unassisted by glasses, they hold a printed page, or other ordinary object, at an unusually great distance from the eye in the effort to see distinctly. Some people are born with this defect of sight, but most people encounter it as age advances ; and hence it is known as *far-sight* or *old sight*.¹ In far-sightedness the cornea, or the lens, becomes *less convex*, or the eyeball shorter from front to back, than when in a normal condition ; the lens being too near the retina, the rays do not focus on reaching the retina so as to produce a clearly defined image of near objects. In such cases, *convex glasses* should be worn to assist in converging the rays on the surface of the retina. In the same person, one eye may be near-sighted and the other far-sighted, necessitating the use of a concave glass for one eye, and a convex glass for the other.

30. Recognition of Color and Color-Blindness. — What charming variety is given to the objects in the world around us by the colors they exhibit ! A colorless world would be a dismal abode. Shades of darkness would afford a delightful variety in comparison.

31. A ray of pure light as it comes from the sun is white. While we cannot discuss here the theory of light and color, it must suffice to say that the colors of the *spectrum*, or the rainbow colors, are blended in an infinite number of ways, giving rise to all the shades and tints we observe in nature.

32. The colors of objects are due to the wave-lengths they set up in the ether which carries the impulse to the eye. The falling of these waves, or vibrations, upon the expansion of the retina is sufficient to give rise to all

¹ *Presbyopia*, or long sight.

those feelings which we term sensations of light and color.

33. *Color-blindness* is a difficulty, more or less great, in distinguishing colors, some of which are entirely confounded by many people who are color-blind without knowing it. The most common form is an inability to distinguish between rose and gray, or red and green. It may arise in a defect in the retina which renders that organ unable to respond to different vibrations of light, and consequently insensible to red, green, or other rays, or in some fault in the conduction of the impulse to the brain. It is not possible to state in what the disability absolutely consists; but it is a lack of power in some part of the optic apparatus to discriminate or co-ordinate the sensations. A physical cause inherent in the individual is probably at the bottom of it.

34. While color-blindness is merely unfortunate for most people in whom it exists, it may become exceedingly dangerous when either knowingly or unknowingly possessed by railway employees or by those in charge of vessels upon the waters. Human life and valuable property often depend upon the ability to recognize the colors of lights without mistake.

35. *Visual Judgments.* — The knowledge we obtain concerning the form, size, distance, and color of objects is called *visual judgment*. An infant sees a ball which to him seems near, yet is really so distant that his struggling efforts to clutch it are futile. It appears to him flat, or a mere disc, and he cannot discriminate between its color and one of another color. He may see the difference but cannot recognize it again, at once. In short, he has a *visual perception*, but has not yet attained *visual judgment*.

36. Visual judgment is the result of the association of other senses with that of sight in regard to the size, form, distance, etc., of objects. We measure the distance of an object with the eye by movements of the eyeball and by adaptation of parts, so that the object is properly focused. We measure the object itself, the distance of its various parts from the eye, and in this way also obtain an idea of its form. We appreciate its color by the wave lengths it brings to the eye and impresses upon its sensitive retina. We know, for instance, the size of an object near the eye, and we thus gauge its size, when further removed, by this standard distance. When the object is removed to a greater distance it appears smaller; but we know, through repeated experiences, that it is not smaller, and that all objects afar off look smaller than when near. Hence the element of distance comes in to modify our estimate of size, and we form a visual judgment from previous experience.

37. We further obtain by the sense of touch a conception of the shape of an object. A repetition of such experiences becomes an impression stored in the mind. So the appearance of a round or a square body becomes known to us by means of the rays of light which proceed from it, without having to confirm our visual judgment by aid of any other sense than that of sight.

38. An object is usually viewed with both eyes, and this assists very much in forming our ideas of its shape and size. Thus when a body of moderate size, which has been ascertained by touch to be solid, is viewed with both eyes, the images of it formed on the retinas are necessarily different, one showing more of its right side, the other of its left. Notwithstanding, the images are cast

upon corresponding parts of the two retinas, and are combined into a single image which gives the impression of solidity. The well-known instrument called the *stereoscope* is constructed on this principle, being so contrived as to throw the images of two pictures of a solid body upon the retinas of the eyes in the same way that these would be received if they really proceeded from one solid body.

39. The connection between the impressions forwarded by the retina through the optic nerve and that act of the brain itself which constitutes the true sense of sight, is mysterious. We only know that it is the brain that sees ; that though the eyes be open during sleep, no evidence is shown that sight is present, or that recognition is taken of objects placed before them.

40. **Optical Delusions.** — Delusions of the judgment through the sense of sight, called *optical delusions*, are more numerous than those of any of the other senses. This arises from the fact that so great a number of what we think to be simple sensations of sight are really very complex combinations of sight, touch, and recollections of former sensations and judgments, all tending primarily to confusion of visual judgment, or *optical delusion*. It is not necessarily a derangement of the nervous system that causes delusive visions. People in the full possession of their faculties and of high intelligence may be subject to such appearances.

CHAPTER XXXIII.

HYGIENE OF THE EYE AND CARE OF EYESIGHT.

1. Conditions Essential to Perfect Sight. — In many cases, even in the young, there is some abnormal condition affecting the sight. In studying the structure of the eye we found a number of parts the perfect condition and correct relative positions of which are necessary for perfect vision. Thus, the cornea must be properly curved and perfectly transparent; the aqueous humor must be clear and sufficient in quantity to fill its proper space; the iris must hang perfectly free, and the pupil be capable of contraction and dilation under the stimulus of light; the lens must be perfectly transparent, and capable of adjustment to long or to short vision; the vitreous humor must be transparent; the retina must be free from congestion, and adhere to the choroid coat; the dark pigment of the choroid must be sufficient to absorb light and prevent its reflection; and finally, the optic nerve must be healthy, in order to conduct impressions correctly from the retina to the brain. Any defect in these conditions constitutes disease, and necessarily renders sight imperfect.

2. Rules to be observed in the Ordinary Care of the Eyes. — When we observe how little attention is given to the proper care of the eyes, and how greatly many people over-tax them under improper conditions of light and position, we should not be surprised that there is so much

defective sight, and that diseases of eyes are so numerous. While defects of vision are frequently inherited, much imperfect sight is induced by lack of ordinary care or by abuse of these organs. Thus, the majority of persons appear to consider it necessary to face a strong light in order to see distinctly while reading, or when performing any kind of fine work. Many others strain and weaken their eyes by reading in railway cars where the jarring is so great as to render it impossible to hold the page steadily, or to keep it at a proper focal distance. Others, through carelessness or uncleanness, convey poisonous or irritating substances into the eyes by unwashed fingers; and very frequently a particle of dust lodged in the eye causes still others to indulge in vigorous and continued rubbing which irritates and inflames the membranes to such an extent that sight is temporarily lost. These, and other similarly careless abuses of the eye and sight, are so important as to require a few general guiding rules for the care of the eyes:—

3. Regarding the position of the body in relation to the light, the left side or the back (preferably the former) should be turned toward the light, whenever it is possible, so that the eye may be protected from excessive light, while the book or work is fully and properly illuminated. This rule applies both to sunlight and to artificial light. In facing a strong light, the pupils contract to shut out a portion of it, and thus the rays from the object viewed are also shut out to some extent, causing the sight to be less distinct. When it is not possible to avoid facing the light, shades should be so employed as to screen the eyes, while admitting of the illumination of the object under view. School desks should invariably be so placed that

the pupils may receive the light from windows on their left. In short, irritation and weakening of the eyes and impaired sight may be avoided by taking proper position in relation to the light.

4. While a book or paper is being read, it should be held, or otherwise kept steadily and firmly, at the proper focal distance from the eyes. If this is not done the eyes are weakened, and soon permanently injured, by the irritation caused by the rapid and continuous changes of their adjustment in the effort to retain the focus of the print. Inclining the head too far over the book or work tends to cause congestion of the blood-vessels of the eyes, and should be avoided.

5. The eyes should not be frequently or continuously employed when light is deficient, or lacking in uniform brightness. Efforts of the eyes to see under such conditions are very taxing on their powers, and weakened sight is the consequence.

6. When the eyes are employed upon fine work, they should be rested occasionally in looking at more distant objects, or by closing the lids and thus obtaining momentary repose. This should be done *before* the eyes begin to feel wearied by long-continued application.

7. The hands should be carefully washed after handling any poisonous or irritating substance, and especially after dressing a sore or other diseased part from which there is a discharge of matter. If this is not done, particles of poisonous substances that adhere to the fingers may be conveyed to the eyes and cause serious inflammation. A towel that has been used by a person who has sore eyes should not be used by another until after it has been thoroughly washed; and the wash-bowl or basin should be similarly avoided.

8. When cinders, dust, or other particles get into an eye, rubbing should be entirely avoided, as it causes increased irritation and does not help to remove the intruder. If the lids can be closed for a few moments, an increased flow of tears will probably wash the irritating particle toward the inner angle of the eye, from which it may be removed by wiping with a soft handkerchief. If this process fails, the lower lid may be pushed upward, while the upper lid is drawn outward and downward so as to overlap the lower lid, thus causing the lower lashes to sweep the eyeball and the under surface of the upper lid, and to remove any particles that may be adhering to the surfaces. If the object is under the upper lid, it may also be readily removed by turning the lid upward over a pencil, or similar instrument, and wiping the surface with a soft handkerchief.

9. If a piece of steel, glass, or any other hard substance becomes imbedded in the eye-ball so that it cannot be safely removed by simple means at hand, the eye should be closed and covered with a dampened cloth, and prevented from moving by a slightly compressing bandage till a competent surgeon can be consulted.

10. If lime or any other caustic substance gets into the eyes, the lids should be opened immediately, and sweet olive oil freely applied to the irritated parts. If the oil is not obtainable at once, bathe the eye similarly with a weak solution of vinegar in water (a teaspoonful of vinegar to half a glass of water), and consult a physician as soon as possible.

11. Whenever the eye has sustained an injury of any kind that appears, or is, at all serious, it should be loosely bandaged in order to exclude light and prevent motion ;

after which the services of a surgeon should be sought immediately. It is best to recollect in all such cases, that delay is probably fraught with danger, especially in relation to so delicate an organ as the eye.

12. In reading while lying down, the book or paper cannot easily be held in the position and at the distance required for the accommodation of the muscles and other apparatus of the eye, and they are over-strained. This habit should be abandoned by all who would retain unimpaired sight.

13. The eye and its appendages require cleanliness, and should be carefully bathed to remove dust and impurities. Moderately cool water is the best eye-wash for healthy eyes.

14. Whenever the sight shows a tendency to become imperfect, consult an oculist without delay in order that timely means may be employed to restore its powers, or to prevent further impairment.

15. An eminent oculist advises persons desiring to retain good eyesight to avoid the use of stimulants and narcotics (alcohol, tobacco, etc.); to avoid sudden changes of extremes in light; to avoid reading while lying down; to rest the eye by looking at objects at a distance; to be careful in matters of hygiene in relation to general health, as these are intimately related to good sight; to bathe the eyes twice a day in cool water until about forty years old, after which age bathe them with warm water; do not rely entirely on your own judgment in the selection or use of glasses, and do not be afraid of an operation for the removal of *cataract*.

16. **Defects of Sight requiring Spectacles.** — The tendency of a neglected defect in vision is toward increased defect.

Certain defects, as we have seen, may be corrected by the use of suitable spectacles, and their importance as a correcting agent cannot be over-estimated. The eyesight of thousands of persons, young and old, becomes further impaired by delay in procuring and using properly selected glasses. In many cases, defect in sight is first experienced in attempting to read small print, or in doing fine work by a dim or artificial light; and in such instances, if the use of glasses is postponed for any length of time, the eyes change rapidly and will soon require more powerful lenses.

17. In the selection and use of glasses when vision begins to be impaired, the following rules prescribed by ocular science should be observed:—

First, as soon as it becomes evident that it is necessary to hold ordinary print either nearer to or farther from the eyes than formerly, or as usual in good sight, procure properly adjusted spectacles, *intrusting their selection only to a competent oculist or optician.*

Second, spectacles should not be used during clear daylight until it is discovered that the object needs to be brought nearer the eye than formerly; or in other words, till the “near point” begins to recede.

Third, single eye-glasses should never be used (especially when the eyes are equal in power), as they give rise to a difference in the focal distances of the eyes.

Fourth, in far-sightedness the glasses used in viewing near objects should not be employed for viewing distant ones.

Fifth, ordinarily the first spectacles used should not magnify, but merely rest the eyes while viewing small objects. For this purpose, lenses of very low power should be selected.

18. Eyesight usually begins to fail naturally between the ages of thirty-five and fifty, varying according to the habits and occupations of different individuals.

CHAPTER XXXIV.

HEARING. — THE EXTERNAL AND THE MIDDLE EAR.

1. *Location of the Ear, etc.* — The organ of hearing, the *ear*, is probably the most complicated organ of special sense. It is not placed on the face, like those of sight, smell, and taste. Its most delicate and important parts lie deeply hidden in the hardest bone of the body, at the base of the skull; but still we may say that, in a sense, it belongs to the face because of the part it plays as one of the elements of physiognomy, contributing not a little to the expression of the face and head in general. The pavilion of the ear stands out from the head and is projected forward, its outline being in beautiful harmony with the contour of the skull and oval of the face; and the artist studies the auricle in its relation to these. Any departure from its normal outlines is at once recognized as an incongruity; and thus in the famous statue of the Faun, by Praxiteles, the pointed tops of the ears give to the whole a weird and inhuman expression.

2. The location of the innermost regions of the ear, deep in the solid bone of the skull, has made the extremely complex nature of these parts all the more difficult to study. Anatomically, the ear is divided into three regions, called respectively the *external*, the *middle*, and the *internal* ear.

3. Divisions of the External Ear. — The external ear comprises the *auricle* (the part commonly called “the ear”) and the *auditory canal*. The tympanic membrane, or drum-head, stands as a partition between the external and the middle ear, at the inner end of the auditory canal.

4. The Auricle. — The auricle is a curiously formed shell of cartilage covered with skin which closely fits all the

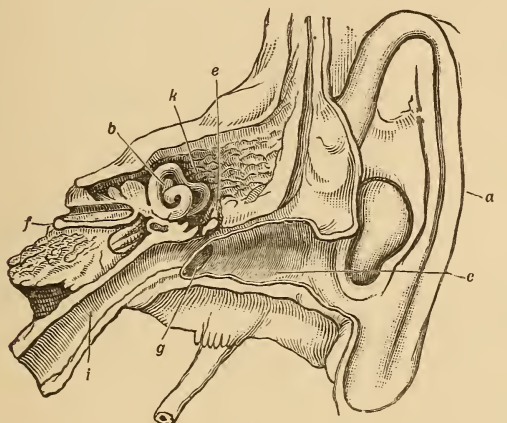


Fig. 56.

EXPLANATION.

a, the external ear.
b, the canals of the labyrinth.
c, the auditory canal.
e, the anvil-bone.
f, the cochlea.

g, the tympanic membrane.
k, the middle ear (tympanum), in which
 the little bones are placed.
i, the Eustachian tube.

ridges and grooves of the underlying gristle. Concave on its outward and forward surface, and convex on the opposite side, its shallow, trumpet-mouth form serves as a collector and strengthener of the weaker sounds which fall upon it — sounds that, in the absence of the auricle, would be lost to hearing.

The surface of the auricle is covered with downy hair, and at the entrance of the canal there are stiff hairs which might be called the "lashes" of the ear. These latter aid in protecting the ear against entering dust, insects, etc.

5. The Auditory Canal. — This canal may be said to be the tube of the acoustic trumpet, of which the auricle is the flaring mouth. It is a tube about an inch and a quarter long, and one-quarter of an inch in diameter, closed at its inner extremity by the drum-head. (See Fig. 56.)

6. The lining-skin of this canal contains, in addition to the glands common to the skin, the ear-wax glands, of which there are more than one thousand.

7. The wax-glands resemble the sweat-glands in structure, and they secrete and pour out the ear-wax, which is of the greatest importance to the health and comfort of the passage. Smearred with this wax, the skin of the outer end of the canal is free from irritation and itching; and the glutinous and peculiarly bitter nature of the wax is a protection against the entrance of insects.

8. In addition to its function of conducting sounds, the auditory canal has the ability to cast out surplus wax that accumulates in it. The mouths of the wax-glands lie near the entrance of the canal. From this point outward the canal inclines, or is "down-hill," while in the opposite direction it slopes toward the drum. This being so, any loose particle of wax naturally tends to slide or roll out of the ear. Such particles will not pass inward, "up-hill," unless pushed in, as is often the case in attempts to remove them by means of ear-picks, pin-heads, etc. Furthermore, the skin of the drum-head and of the canal grows outward, and has a tendency to carry out dirt

and wax, thus doing its own sanitary work when not interfered with by unnecessary swabbings and scrapings.

9. The Tympanic Membrane, or Drum-Head. — This membrane is the dividing partition between the auditory canal and the drum-cavity of the middle ear. It is nearly circular, and about one-fourth of an inch in diameter. It consists of three layers, the outer one a continuation of the skin of the canal; the middle one of fibrous tissue (the thickest layer); and the inner layer of mucous membrane. Its edges are attached to a bony rim in the side of the skull.

10. Stretched somewhat like the head of an ordinary drum, it performs similar service. The sound-waves beat upon it and cause it to vibrate, back and forth, thus communicating motion to the chain of little bones, the first link of which is attached to its inner surface. The vibration of this membrane is the first step in the process of bringing the impulse given by the air-waves into contact with the nerve of hearing.

11. Divisions of the Middle Ear. — The middle ear is located, as its name would imply, between the external ear and the internal ear. It is a small, irregular air-chamber, hollowed out in the hard portion of the temporal bone, and its principal occupants are the little bones of hearing, the smallest bones of the body. The middle ear comprises the *tympanum* and its important adjuncts, the *Eustachian tube* and *mastoid cells*.

12. The Tympanum, or Drum. — This cavity is nearly half an inch in height and in length, and from a twelfth to a sixth of an inch in depth. It is lined with mucous membrane, and is the most delicate and complicated division of the middle ear. It is the *drum* proper, and is the only

part of the ear to which the term "drum" should be applied. Confusion results from speaking of the tympanic membrane as being "the drum." This cavity and its appurtenances are the portions of the ear most liable to diseases.

13. *The ossicles, or auditory bones*, are four in number, and are joined together so as to form the so-called "chain of bones" stretching from the drum-head through the drum-cavity to another membrane which covers a small hole in the opposite side of the cavity. These bones, named from their resemblance to the implements, are the hammer, or *malleus*; the anvil, or *incus*; the round bone, or *orbicularis* (the smallest bone); and the stirrup, or *stapes*. (Fig. 57 represents these bones of their natural size, except the round bone, which is magnified. Passing into the drum, the first bonelet of the chain we meet



Fig. 57.

is the hammer, the largest of the four, being about a quarter of an inch long, and having its handle attached to the inner surface of the drum-head. Next in order is the anvil, which is a little smaller than the hammer. Third comes the round bone (found in the ear of the young, but later it becomes part of the anvil); and fourth the stirrup, whose foot-plate is firmly joined to the membrane (similar to the drum-head) in the opening into the inner ear.

14. Joined one to an extremity of another, they form a bridge between the drum-head and the entrance to the labyrinth, and are held in position by ligaments which fasten them to the roof and walls of the drum-cavity. When the drum-head vibrates under the force of a sound-wave, the linked bonelets swing inward and transmit the vibrations to the membrane in the oval window of the

labyrinth, or internal ear, and thence make an impression upon the nerve of hearing.

15. The Eustachian Tube.¹ — This tube is the only natural air-duct between the throat and the drum-cavity. Opening in the back of the throat (pharynx), above the palate and a little below the floor of the nostrils, it passes upward, outward, and backward to the middle ear. Its length is somewhat more than an inch; and its openings in the throat and in the drum are wider than the "isthmus," midway of its length, where it is one-sixteenth of an inch wide. About two-thirds of the tube is cartilage, the third next to the ear being bone.

16. Every act of swallowing has the effect of opening the mouth of this tube in the throat; air then enters it and passes through into the drum-cavity, thus keeping the pressure of air equal upon the inner and outer sides of the drum-head. In the military drum this is provided for by means of a hole in the side, which allows air to pass freely in and out, in order that the vibration may be perfect.

17. The air within the drum-cavity is soon absorbed and a partial vacuum is caused, when, for any reason, the Eustachian tube is closed. The pressure of air upon its outer side then forces the drum-head inward, the little bones are pressed upon each other, and so locked as to be unable to swing freely; hence, a closure of this tube is a common source of deafness. In yawning, the tube is compressed and its walls adhere for the moment, causing the peculiar roaring in the head that all have experienced. A crackling sound is heard on the removal of the compression, and all is right again.

¹ *Eusta'chian*, from Bartholomeo Eustachi, a celebrated Italian anatomist (died 1574) who first gave a description of the tube.

18. A blow upon the ear, or an explosion, forces the drum-head suddenly inward, driving the air in the drum-cavity into the Eustachian tube, and even into the throat, thus allowing the drum-head to "give" and saving it from rupture. Gunners, often without knowing why, open their mouths when firing, and thus allow unobstructed egress of air from the Eustachian tube.

19. **The Mastoid Cells.** — These are a set of spongy bone-cells within the cavity of the mastoid-bone, which may be felt as a rounded prominence back of either ear, and they are lined, like the drum-cavity, with mucous membrane. These cells contain air, and unite with the Eustachian tube by a sort of funnel. The function of these cells is to increase the amount of vibratory surface, and thus to aid in hearing deep tones; for, in order that the drum may properly receive deep sounds, it must have depth and capacity, and hence its connection with the mastoid cell-cavities.

20. On its inner side a very thin wall of bone separates the mastoid cavity from one of the large blood-vessels of the brain; and, as this cavity readily partakes in the diseases of the drum, this thin wall soonest gives way to disease, and infectious matter thus passes from the cavity to the brain.

CHAPTER XXXV.

THE INTERNAL EAR, AND HOW WE HEAR.

1. **Divisions of the Internal Ear, etc.** — The *labyrinth*,¹ or internal ear, is, as its name indicates, an extremely complicated division of the organ of hearing; and the functions of many of its parts are not clearly known. It consists of a central cavity which communicates with spiral tubes and winding channels, all of which are lined with mucous membrane and filled with water. The filaments² of the nerve of hearing are spread out in the lining of these passages; and it is the function of the internal ear to receive the impressions of sound and to transmit them, by means of the auditory nerve, to the brain. While the middle ear is an air-chamber, the internal ear is a water reservoir. Its divisions are a central chamber, or *vestibule*; the spiral tubes, or *cochlea*; and the *semi-circular canals* — all forming a continuous cavity.

2. **The Vestibule.** — This is the central, egg-shaped portion of the labyrinth between the semi-circular canals and the cochlea. It communicates with the drum-cavity by means of two small openings, which, from their shapes, are called the *oval window* and the *round window*. In the living body these “windows” are closed by firm mem-

¹ LAB'-Y-RINTH (Gr. *laburin'thos*). A maze; a building with many winding passages.

² FIL'-A-MENTS, tiny, thread-like ends.

branes, similar to that of the drum-head. The foot-plate of the stirrup-bone is joined firmly to the membrane of the oval window, and thus the connection between the drum-head and the labyrinth and nerve of hearing is made complete by the chain of little bones.

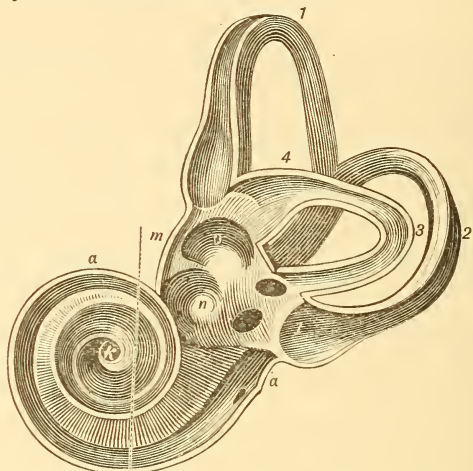


Fig. 58. — Interior of the Left Labyrinth, highly magnified.

EXPLANATION.

a to a, the cochlea; *k*, the hollow axis about which the two canals wind two and a half turns; 1 to 4, the semi-circular canals; *m*, the vestibule, in which are *n*, the fenestra rotunda (round window), and *o*, the fenestra ovalis (oval window).

3. The Cochlea, or Snail-shell. — This portion of the internal ear is a bony tube twisted two and a half times about a bony pillar, being similar to a snail-shell. It is divided, in part, into two spiral passages by a bony shelf. If an insect could leave the vestibule opposite the oval window, it might pass into the upper of these spiral stairways, crawl to the summit, and descend by the lower stairway to the round window

4. The nerve of the cochlea, after passing into the bony pillar, divides into many tiny branches of varying length which spread out upon the bony shelf, like the strings of a harp or piano, and form the so-called "organ of Corti." Physiologists have reason to think that this organ is specially designed to receive impressions of musical sounds as distinguished from others which are received by the nerves of the vestibule.

5. **The Semi-circular Canals.** — This is the name given to three curved tubes. They are each enlarged into a bulbous cavity at one extremity.

6. It has been found, through experiment, that when these canals in the ears of birds, or other animals, are injured or destroyed, such animals are then unable to control their movements in flying or walking. In certain instances of ear-disease in man, similar staggering and falling occur, and are supposed to indicate that the semi-circular canals are affected. These facts have led to the supposition that there resides in these peculiar canals a sense of balance of the head and body. However this may be, it is certain that they present additional surface for the distribution of the auditory nerve.

7. **Sound and its Nature.** — Sound is an impression made in the ear by the vibrations of elastic bodies, transmitted through the air or some other medium. We may compare these vibrations to the little waves which ripple the surface of a pool when a stone has been thrown into it — spreading out in every direction from a centre, but growing smaller as they recede, till at last they are no longer perceptible.

8. All vibrations do not produce sound ; some are too slow to affect the ear, and, on the contrary, others are

too rapid. When there are less than 16, or more than 38,000, vibrations per second, the ear is not affected by them.

9. Sound moves more rapidly in warm air than in cold. When the temperature of the air is at 62°, Fahrenheit's thermometer, sound travels 1,120 feet per second ; and its velocity is increased or diminished by the wind, according as it blows toward the ear from the sounding body or in the opposite direction. While air is not absolutely necessary to the transmission of sound, sound cannot be produced in a vacuum ; and hence it is less intense in rarefied air, as upon the tops of lofty mountains. Liquids and solids are better conductors of sounds than air ; thus, water transmits sound $4\frac{1}{2}$ times as rapidly as air ; iron, 10 times ; and different kinds of wood, from 11 to 17 times more rapidly.

10. *Loudness* of sound depends on the extent of the vibrations, or breadth of the sound-waves ; *Pitch* depends on the rapidity of the vibrations — the more rapid, the higher the pitch ; *Quality* of sound depends on the nature of the vibrating body.

11. **How we Hear.** — When a sound-wave reaches the side of the head, part of it is received by the auricle and directed into the auditory canal. Flowing on through this tube at the rate of 1,120 feet, more or less, per second, the waves arrive at the drum-head, beat against it, and throw it into a to-and-forth motion. The drum-head imparts its motion to the hammer-bone, and this to the other bonelets, causing the entire chain to move back and forth, like a pendulum. By this means the foot-plate of the stirrup-bone is caused to move in and out with the membrane of the oval window of the vestibule, compressing

the liquid contained in it, and setting that in motion. This action of the liquid is communicated to the soft parts of the labyrinth, in which the nerve lies, and the perception of this movement by the nerve-threads of the auditory nerve and the brain constitutes hearing.

CHAPTER XXXVI.

HYGIENE OF THE EAR AND CARE OF HEARING.

1. **Care of the Auricle.** — *The auricle should receive moderate, careful washing* with a wash-cloth rather than with a sponge. It should be thoroughly dried after washing, for any moisture left upon it, upon the prominent bone behind it, or in the hair surrounding it, will evaporate and chill the ear, cause “cold,” and lead to catarrh. After a bath, it is the custom of many people, particularly of women, to sit in a draught to dry the hair. This practice leads to colds, ear-ache, and impaired hearing. A little good Castile soap is the safest in washing the auricle—any soap that sours should not be used about the ears or elsewhere upon the body.

2. *Suffering from cold ears* may be guarded against by a light ear-muff, a piece of cotton-wool put lightly in the ear, by ear-laps attached to the hat, or by a light woollen scarf. The entire ear, however, may be made tender by constantly wearing cotton in it while indoors; and the ear-wax may be packed inward and hardness of hearing caused by this practice.

3. *A frost-bitten auricle* becomes dead-looking and very brittle. Care should be taken lest it be broken, and also

that warmth be not restored too quickly. If heat be applied, intense pain will follow, and inflammation may set in — the ear appearing as if burned instead of frozen. The circulation of the blood should be restored gradually; and this is done best by rubbing the frost-bitten part with snow or ice till feeling is restored, when the auricle is safe.

4. *Blows on the auricle* may injure the ligaments that hold it in place; and inflammation may extend from these to the underlying bone, resulting fatally.

5. *Piercing the auricle for earrings* may communicate disease from one person to another, unless care is taken to thoroughly cleanse the piercing instrument from all adhering putrefied matter, after each operation.

6. *Care of the Auditory Canal.* — This tube must not be obstructed by wax, and yet must be well supplied with it. Wax, being necessary to the health of the ear, should not be regarded as “dirt,” and, as such, constantly scraped away. The use of scraping instruments cannot be too strongly condemned. They not only pack in as much wax as they remove, but also abrade the skin of the canal, causing it to become inflamed or to send out moisture which putrefies and sometimes induces the growth of mould or *fungi*.

7. *The use of sweet-oil, glycerine, etc.,* has a bad effect. Sweet-oil, while not having good solvent effect upon hardened ear-wax, tends to become rancid when forgotten in the ear, and thus, besides increasing pain, provides rich soil for the growth of mould. Glycerine has the power to dissolve hardened ear-wax, but it has great affinity for water, and hence acts like a caustic, burning and stinging the ear. It should be mixed with at least eight times its quantity of water when used in dissolving ear-wax.

8. *Syringing the ear is the only proper means of cleansing the auditory canal*; but neither cold water nor other cold liquid should be injected. Warm water, moving easily and without jerks, should be used; the nozzle of the syringe being held close to the tube, but not thrust into it.

9. *An insect in the ear-tube* may be removed by dropping in a little sweet oil, which will either cause the insect to crawl out or will smother it, in which latter case syringing the canal will float the intruder out.

10. *A hard foreign body in the ear-tube* may usually be removed most easily and successfully by forcing it out gently by syringing. In case, however, the object in the ear is a bean, a pea, or a corn grain, etc., too long continued use of the syringe would soften and swell it, thus delaying its removal.

11. *Do not probe the ear to remove objects from it.* If a foreign body cannot be removed by syringing, you may be assured that it will not pass beyond the reach of the surgeon's skill. It cannot reach the brain, or even the middle ear, unless you push it in through the drum-head. Let it alone — the skill of the surgeon is now required in its removal.

12. **Care of the Drum-Head.** — *In swimming or diving* — particularly the latter — cotton should be placed in the ear-tube to prevent the entrance of cold water, and consequent inflammation of the drum-head.

13. *Bathing in the sea and surf has dangers for the ear.* The direct force of the waves dashing into the ear has caused the rupture of the drum-head and produced permanently defective hearing. Besides, the coldness and stimulating nature of sea-water irritate the canal and drum-head. In sea-bathing the ear should be protected by cotton.

14. "*Boxing the ears,*" and *concussions from unexpected explosions*, are common sources of injury to the drum-head. These coming suddenly, the membrane is not prepared to resist; and if the Eustachian tube is temporarily closed at the time, rupture of the drum-head is probable. Opening the mouth when an explosion is expected, for reasons already explained, relieves the drum-head from much of the concussion. When a rupture of the drum-head is either suspected or known, put nothing into the ear. Any liquid put into the canal would pass through the fissure in the drum-head into the drum-cavity, and thus cause inflammation. Instead, put a little dry cotton in the entrance of the canal, and usually the ruptured drum-head will heal. Any force sufficient to rupture the drum-head may, by concussion, injure the deeper and still more delicate portions of the ear, causing permanent deafness. A severe blow or a fall upon the head may be the cause of deaf-dumbness in a child if the injury occurs before he has learned to talk.

15. *Shouting loudly and suddenly into a person's ear* is an ignorant or vicious trick; besides the shock to the nervous system, which is sometimes disastrous, it may result in permanent deafness. The trick is too dangerous to be tolerated.

16. *The noise of boiler-making and loud clatter of machinery* affect the ear badly. The constant and severe shock of these noises finally exhausts the nerve-power. Much of the bad effect may be guarded against by wearing something over the ear while it is exposed to them.

17. *Care of the Eustachian Tube.* — *All possible care must be taken to keep this tube free from obstruction* if hearing is to remain perfect. If, after a cold in the head or a sore

throat, the tube is allowed to remain closed, it may, through inactivity, become entirely unable to open and admit air into the drum. A vacuum is thus created, the drum-head falls inward, the entire hearing apparatus is thrown out of order, and deafness sets in.

18. *Breathing through the mouth is injurious to the throat and to hearing.* Mouth-breathing, which is most frequently occasioned by allowing the nostrils to remain clogged with mucus, causes the mouth and throat to become dry, and the Eustachian tube to become irritated and closed.

19. *Catarrh snuffs, and liquids* for snuffing into the nostrils, produce ear-diseases. These preparations are sometimes drawn directly into the Eustachian tube, clog it, or cause inflammation in the drum-cavity.

20. *Effects of Alcoholic Drinks and Tobacco on the Ear.*—The use of much alcoholic drink injures the ear, directly, in at least two ways: 1st, by inflaming the throat, and, by that means, the Eustachian tube and middle ear; 2d, by congesting the blood-vessels of the internal ear. To these may be added its bad effects upon the nervous system, of which the nerve of hearing forms a part.

21. *The use of tobacco, in all its forms, is severely and generally condemned by aurists.*—Chewing is apt to cause catarrh of the throat; and snuffing, catarrh of the nose—each thus tending to induce ear-disease and impaired hearing. Tobacco smoke, especially when blown through the nostrils, is brought directly to the mouth of the Eustachian tube, and may produce inflammation there; hence, the smoking of cigarettes is supposed to be more especially harmful. The atmosphere of a smoke-filled room is irritating to the nose and throat, and therefore to the ear.

CHAPTER XXXVII.

TASTE AND SMELL.

1. **Taste and Smell Compared.** — In many respects taste and smell are twin senses. Among the substances which we taste, there are few that address themselves solely to that sense, and not at the same time to the sense of smell. Flavors and odors are so mingled together in the same substance, and the action of the senses which perceive them so nearly simultaneous, as to induce some authorities to consider them as one. They are, however, quite distinct in their location and in several important functions; the mixed sensations resulting from the union of the impressions of taste and smell are quite different from those caused by each separately. It may therefore be said that the sense of smell is the necessary complement of the sense of taste, as the latter becomes very much weakened and less in importance when deprived of the assistance of the former.

2. These senses aid in the determination of what is pleasant or disagreeable, wholesome or unwholesome, to the system in general. The location of the organs at the entrance to the digestive and respiratory cavities of the body suggests that they are sentinels to warn us in regard to the character of substances brought into contact with them, and thus to afford the reason and the judgment opportunity to decide whether they are good

or bad, innocent or harmful. It is true that we are frequently deceived by these senses in regard to the wholesomeness of substances with which we have not become familiar through experience. Many baneful matters are pleasant to taste and to smell; and this fact proves that our reason and judgment are to be employed as correctors of our senses, and that the latter are not to be trusted alone.

3. The brute creation, which depends more fully upon animal instinct, have all the special senses strongly developed and correspondingly acute.

4. **The Organs of Taste.** — Physiologists do not all agree in locating the portions of the tongue and mouth that are sensitive to taste. Some believe that the seat of taste extends over nearly the whole surface of the tongue, to the fauces, to the upper surface of the soft palate, and to the pharynx. The belief is quite general, however, that it is located at the tip, sides, and base of the tongue, and on the front surface of the soft palate, to all of which branches of cranial nerves are supplied.

5. The *tongue* not only participates, by its movements, in the digestive process and in the articulation of sounds, but its special sensibility constitutes it also the principal organ of taste. It is a muscular organ covered with mucous membrane. Its upper surface is rendered rough by numerous small conical elevations called *papillæ*, all of which are richly supplied with blood-vessels and nerves. Those at the root of the tongue are large, and are arranged in two oblique rows forming a V-shaped figure, with the angle directed backward; those at the tip and edges of the tongue are smaller and more numerous.

6. It appears that, in order to produce the sensation of

taste, the particles of substances must be brought into actual contact with the nerve-fibres in the papillæ by penetrating the outer layer of mucous membrane which covers them. It is therefore necessary that substances to be tasted must either be already in solution, or must be capable of being dissolved by the saliva of the mouth, in order that they may easily penetrate to the terminations of the nerves of taste. Dry substances, or those incapable of being dissolved, do not produce a sensation of taste. The salivary glands supply all the moisture that is ordinarily required to moisten food and bring out its flavor; but during fevers the supply of saliva is lessened, the mouth becomes dry, and the pleasurable sense of taste is almost wholly lost.

7. Curiosities of Taste. — The nerve-fibres of the tongue and palate are derived from two sources, one² of which supplies the middle and tip of the tongue, the other¹ its back and the adjacent parts of the palate, etc. There is reason to believe that both these nerves are nerves of taste, although they are not precisely similar in their functions. Sweet and salt tastes are perceived more readily at the tip than at the back of the tongue. Sugar may be placed on the back of the tongue without producing any sensation of taste. Bitter flavors are soonest detected when applied to the back part of the tongue, and acids when applied to its edges.

8. A very large number of the sensations which we call taste are not simple, but complex, in which smell, and even touch, are factors. Smell is so closely related to taste that the odor of a substance often suggests its taste. When the sense of smell is obstructed, as when the nos-

¹ The *glossopharyngeal* nerve.

² The *gustatory* nerve.

trils are pressed together, or during a severe cold, or when it has been destroyed by catarrh, it is either difficult or impossible to distinguish the flavors of different substances. The eyes being closed, the taste of an onion may then be mistaken for that of an apple, and *vice versa*. In this we find an explanation of the common practice of closing the nostrils while a dose of nauseous medicine is being taken.

9. As it is not the eye that sees, nor the ear that hears, neither is it the tongue that tastes. Impressions made on the nerves of taste are conducted by them to the brain, where they are recognized.

10. **The Sense of Smell.** — The sense whereby we become cognizant of odors contributes greatly toward the pleasures of life, and it not infrequently warns us of the presence of noxious gases which might destroy it. Placed directly over the mouth, its organs examine the substances which are presented for admission into that cavity, and primarily discriminate as to their fitness. Furthermore, as the passages of the nose are important avenues to the lungs, entering air must undergo an examination by the organs of this sense, and its fitness for the purposes of respiration be subject to their verdict, or rather to that of the brain to which they conduct the sensation. Thus it is seen that under the protecting guidance of this sense, supplemented always by reason and judgment, injury to the body and its health may be avoided.

11. The lower animals depend wholly upon this sense as their guide to proper food, and as a protector from that which is liable to be harmful. To them it is still more important than to man, and its acuteness is proportionate to its necessity.

12. The Organ of Smell. — The seat of the sensation of smell is in the mucous membrane which lines the cavities of the nose. The nerves which are specially devoted to this sense are called the *olfactory nerves* (Lat. *olfactus*, the smell). These nerves, one on each side, separate into an immense number of minute filaments immediately before passing out from the cranial cavity, and each filament passes through a separate little hole in a very thin plate of bone situated immediately over the top of the nasal cavity, between the orbits of the eyes. This delicate, bony plate alone separates, in this region, the brain from the cavity of the nose; the great number of its perforations give it a sieve-like appearance, and hence it is technically called the *cribriform plate* (Lat. *cribrum*, a sieve). Having entered the cavity of the nose, the innumerable nerve filaments ramify in portions of the mucous membrane which lines it.

13. The two irregular air passages leading into the more remote cavities of the nose are separated by a partition¹ of bone and cartilage. The bones at the sides of these passages curve in a scroll-like form, and are covered with a very delicate kind of membrane, containing *mucous glands* which secrete a fluid that moistens it and is of importance in completing the impression of smell. The cavities extend up to the point where the nose joins the forehead, and backward and downward they are continuous with the cavity of the pharynx. The irregular form of the bones, and the winding nature of the cavity of the nose, increase the surface for the distribution of the branches of the nerves of smell.

14. The organ of smell being thus constituted, particles

¹ The *septum*.

given off from odorous substances are carried by the air which is drawn in through the nose and brought into contact with the membrane and filaments of the nerves of smell. This process is facilitated by the moisture of the membrane, which causes the odorous particles to adhere and be retained, thus giving them opportunity to make a more distinct impression on the nerves. The various impressions are conducted by the olfactory nerves to the brain, where they are converted into the sensations known as *smell*, or the sense of odor. How the brain recognizes odor, or how it distinguishes different odors, is not known.

It may be that different odorous substances give rise to different changes in the nerve cells, each distinctive of the odor that causes it; or it may be that certain cells of the brain are adapted to especially recognize impressions made by different particles.

15. When it is desirable to be exact in perceiving an odor, the mouth is closed, and sudden, short inspirations are taken wholly through the nose. This causes upward and sudden rushes of air into the nasal cavities, and disturbs the comparatively still air which is enclosed by the folds of the scroll-like bones, causing some of it to give place to the in-coming air laden with the odorous particles that would not otherwise come in contact with the terminations of the nerves of smell. This practice of sniffing the air to detect odors is common to man and the lower animals, especially to the latter.

16. **Curiosities of the Sense of Smell.** — The sense of smell can be cultivated to a certain degree. A nice discrimination between odors can be attained by practice and observation. It is the education and training of the senses that make the judgment of some persons better than that

of others in regard to the conditions of material things. A trained eye can see beauties and defects ; a trained ear can detect harmonies and discords ; and trained senses of taste and of smell detect flavors and odors that escape observation when these senses are not educated.

17. Simple experiments prove that odorous substances emit invisible streams of particles so small as to seem to be immaterial ; and nothing gives a more exact idea of the divisibility of matter than the diffusion of odors. Half of a grain of musk placed in a room will diffuse its particles throughout the entire space and produce a strong odor for a long time, without apparent diminution of its bulk or weight.

18. "Heat, light, and other influences modify the production of odors and their transmission in space. Certain plants are odorous only at night ; and it is especially in the morning and evening, when the dew is scanty, that flower-gardens perfume the atmosphere. Rain destroys the perfume of flowers, probably by its mechanical action, and by lowering their temperature. It is remarkable also that animal or vegetable odors are feeble as the countries are colder in which the animals or plants live from which they emanate. Hence perfumes come principally from tropical countries."

19. Curious phenomena are exhibited by the sense of smell. Some persons faint on smelling a particular odor, that of a rose for instance, and there is no doubt that certain odors may cause grave disturbance in the nervous system ; but people often ascribe to odors effects which are really produced by carbonic acid gas, or other poisonous emanations, absorbed by the lungs.

20. The proverb which states that "there is no

accounting for taste" applies in the case of fondness for certain odors. Individuals and nations differ singularly in this respect. The Laplander and the Esquimau find delight in the odor of fish-oil, and there are persons who do not find the odor of assafoetida more disagreeable than that of the attar of roses. No doubt familiarity with certain odors, that are at first highly repulsive to the great majority of people, causes them to become not only tolerable, but pleasurable to the sense of smell in some individuals.

21. The sensations of smell and taste are easily confused, one with another. Again, owing to the persistence of the sensations, we cannot discriminate two odors or two tastes when one follows the other in rapid succession, as we can a number of simultaneous touches locally separate from each other.

CHAPTER XXXVIII.

TOUCH.

1. **Touch as a Sensation.** — The sense of touch is sometimes classed among the general sensations, because it is so closely related to *feeling* and *pain*, and is so widely distributed. But we must discriminate between the sense of touch and the sensation of feeling and of pain: touch proper is a sensation by which we gain knowledge through contact with objects in the material world, while feeling or pain may either accompany the pure *sense of contact*, or exist without it, and simply make us aware of certain

conditions of various parts of the body. Touch may therefore be regarded as a modification of the common sensation of feeling, whereby the contact of any object with a sensitive portion of the body reveals its form, hardness, and temperature. Thus feeling or pain may exist without sense of contact or touch. Feeling may be involuntary, while touch is an act of the will; there is, therefore, the same difference between feeling and touch that there is between seeing and looking, or between hearing and listening.

2. To the sense of touch or contact we owe immunity from dangers which often escape the observation of the sense of sight; so delicately sensitive are many portions of the body that the movement of the slightest breeze, or the contact of the lightest feather, is instantly perceived, and the attention is drawn to the precise point of touch.

3. **The Organ of Touch.** — The nerves of touch are located in the skin throughout its whole extent, and in some of the mucous membranes. Wherever the sense of touch is most delicate, the deep layer of the skin is raised up into multitudes of small conical elevations called papillæ. In many of these the nerve-fibres end in a *tactile corpuscle* (see Chapter XXVIII., "*Nerves of the Skin*"). These bodies are especially found in the papillæ of those localities which possess a very delicate sense of touch, as in the tips of the fingers, the point of the tongue, etc. The outer skin covers these papillæ, but dips down between them, and hence no direct contact takes place between an object which is touched and the sensory nerve itself. Slight pressure upon the outer skin creates the impression upon the nerve filaments beneath it. The sensitiveness to touch of any part is proportionate to the number of its

papillæ and the variable thickness of the outer layer of the skin.

4. But all sensations produced by the contact of the skin, etc., with objects are not alike. Combined with the sense of touch, there are frequent sensations of feeling, as of pain, temperature, etc. These varied sensations are difficult of explanation. The feeling of warmth or of cold is the result of impressions made upon sensory nerves which are possibly distinct from those which simply give rise to the sense of touch. In some way the nerve-twigs which end in the papillæ possess the power of discrimination, and the information which they conduct to the brain is there utilized in directing our actions amidst the material forces of the world.

5. **Curiosities of the Sense of Touch.** — Certain phenomena which appertain to the sense of touch are very curious and interesting. Some of these peculiarities are undoubtedly due, in part, to the varying thickness of the epidermis, and to the abundance or the scantiness of the distribution of the special nerve-fibres.

6. When the two ends of the legs of a compass are applied simultaneously to the skin, they must be more or less separated, according to the region experimented on, in order that their contact may cause two distinct sensations of contact, instead of but one. Thus, if the points are separated only one-twelfth of an inch and applied to the tips of the fingers, two distinct impressions of touch are produced, whereas if applied to the back of the hand in the same way, but one impression is perceived; on the arm the points may be separated one-fourth of an inch, on the cheek an inch, and on the back even three inches, and still give rise to only one sensation. The tip of the

tongue, on the contrary, receives two impressions when the points are separated only one-twenty-fourth of an inch. In this way the degree of sensitiveness to touch possessed by the skin of different regions of the body may be measured by its power of distinguishing between two or more impressions at points very near each other.

7. The idea of external objects given by touch often depends upon the possibility of distinguishing the different parts of a body as occupying different places in space. If, for example, a small sphere is caused to revolve between two parallel fingers of the same hand, the impression produced is that of a single body touching both fingers; but if the fingers are crossed, and the ball placed between their extremities, the impression produced is that of two balls, each rolling in contact with one of the fingers.

8. Contact with the same body may produce successive impressions of heat or of cold without a change in its temperature, depending respectively upon the coldness or warmth of the surface of the skin at the moment of contact. Thus, in placing a cold hand upon any portion of the body that retains a normal temperature, that portion appears to be unusually warm; but if the hand is normally warm, the part on which it is placed seems to be much cooler than in the first instance. Again, if a bath is taken in water cooler than the air, the temperature of the air, which seemed low on entering the bath, seems warmer on leaving the bath a few minutes afterward. For the same reason the air of a cellar appears cooler in summer and warmer in winter, although it has not varied.

9. Of two different bodies having the same temper-

ature, one may seem much colder than the other when brought into contact with the skin. Thus, iron appears colder than wood, and water colder than air, at the same temperature. In such instances, the sensation of temperature is strong in proportion to the conducting power of the object in contact with the skin.

10. Unaided by the sense of sight, it is difficult or impossible to distinguish between the sensation produced by an object at a very low temperature and that by one at a high temperature. Contact with the point of an icicle is readily mistaken for contact with a hot iron, and contact with a ball of frozen mercury (-40° Fahrenheit) causes a burning sensation, the same as that of iron heated to 212° Fahrenheit.

11. The hand is naturally the principal instrument for exercising the touch, and it becomes rapidly inured to contact with objects that are so hot as to cause pain to those unaccustomed to such contact. The membranes of the tongue, mouth, and throat, in persons of mature age, often bear, without pain, the contact of food and drink so hot that younger people could not tolerate them.

12. From the foregoing illustrations it is evident that the sense of touch is not a reliable thermometer; and that while it cannot replace the other senses, it frequently corrects their impressions. When we permit its full development, and employ it with the reason and judgment which result from a co-ordination of sensations, it is sufficient to guide us in matters of health related to external objects.

13. **Delicacy of Touch.** — Through cultivation and exercise, touch attains extreme delicacy. The necessities of the blind result in a cultivation of this sense whereby

wonderful facility is acquired in various delicate manipulations ; and persons in various occupations in which great sensitiveness and delicacy of touch are required, attain these in a remarkable degree.

14. Diseases of the nervous system often intensify sensibility to touch ; and, on the other hand, disease sometimes modifies, suspends, or destroys it. In this respect, like the other senses, it is dependent upon conditions which affect the great nerve system, as well as upon local disease of its organs.

15. **The Voice.** — The organ of voice is the *larynx* (see Fig. 37), which is a modification of the upper portion of the trachea. It consists of a cartilaginous framework, the parts of which are movable on each other by means of the contraction of muscles. The upper end of the larynx is nearly closed by two bands of membrane (the so-called *vocal cords*), between which a narrow slit or chink (the *glottis*) is left for the passage of air. The epiglottis, which is not employed in the production of sound, is a lid of cartilage which closes the space between the cords during the act of swallowing.

16. During quiet breathing the vocal cords are relaxed ; but when we wish to speak, sing, etc., certain muscles stretch the cords more or less, and narrow the opening ; and when the air is forced out with sufficient velocity, the cords are caused to vibrate, and sound is produced, — the more rapid the vibration the higher the pitch. In singing, 128 vibrations per second produce the bass C ; 256 the tenor C ; and 512 the treble C. “The power which the will possesses of determining the exact degree of tension which these cords shall receive is extremely remarkable. . . . There must be at least 240 different states of

tension, every one of which can be determined by the will; and the variation in length required to pass from one musical 'interval' to another will not be more than $1\frac{1}{200}$ of an inch."

17. On account of the greater length of the vocal cords, the pitch of the voice in men is much lower than in women; but this difference does not occur until the end of the period of childhood, — the size of the larynx being about the same in the boy and girl up to the age of fourteen or fifteen years, but then undergoing a rapid increase in the former, with a corresponding depth of tone, whilst it remains nearly stationary in the latter.

18. **Effects of Alcohol and Tobacco.** — As both alcohol and tobacco are injurious to the nervous system, they are consequently harmful to the organs of the special senses, one or all of which are more or less impaired by these narcotics.

19. *Smoking* often causes dilation of the pupil of the eye, confusion of sight, bright lines, cobweb specks, etc. Oculists are of the opinion that one of the greatest enemies of the eyes of boys and young men is the *cigarette*, the smoking of which is especially harmful in various ways. More of the hot soot-laden smoke is drawn into the air-passages, and more of the acids and alkalies come in contact with the delicate linings of these, and are absorbed into the blood, than in pipe or cigar smoking. Deaths among the young caused by cigarette smoking are frequently reported, and undoubtedly many more occur from this cause than are publicly made known.

20. Alcohol and tobacco when habitually used *benumb the nerves of taste*, causing them to be incapable of detect-

¹ Carpenter.

ing delicate flavors; and hence, plain food becomes insipid. Resort is then had to highly seasoned food as a spur to the taste. The smoke of tobacco contains many fine particles which find lodgement in the mucous lining of the passages of the nose, causing inflammation and *impairment of the sense of smell*; or, by inducing or aggravating catarrh, sometimes destroying the sense of odor entirely. Even the *sense of touch is rendered less delicate* by these agents which act so powerfully on the nerves.

Suggested Points for Questions.

CHAPTER XXXII. — 1-3. Sensation in general — knowledge obtained through sensation. General sensation defined — examples; character of knowledge thus obtained. Muscular sense — object and peculiarities. 4. Special sensations — whence they arise; stimulus applied to a definite organ — local character; illustrations of; sense organ defined; external objects or causes — basis; special senses named. 5. Sense of sight — importance, functions; sadness of deprivation; sight and touch related. 6-8. Anatomy of eye — location; eyeball — form and protection; eyelids and lashes — functions; eyebrows; tear-gland — secretion and function; nerves, blood-vessels; muscles and their importance to sight — effect of undue contraction or relaxation. Size and form of eyeball — elongation; coats or tunics; refracting mediums; optical instrument. 9-14. Coats, humors, lenses, etc. — sclerotic coat described and functions stated; the cornea described — window. Choroid coat — location, nature, blood supply, pigment cells, principal function — darkening. The iris — location and general structure — aperture, muscular action, contraction of pupil and why; color of eye — source. The retina — location, structure (an expansion of optic nerve), function — receives impressions. Crystalline lens — location, form, size, transparency, capsule and ligament; change of position and curvature — object; office of lens. Spaces or cavities occupied; aqueous and vitreous humors — location, characteristics, and functions of each. 15-17. Appendages — conjunctiva, nature, location, and glands of — functions. Lachrymal gland — location, size, secretion, ducts, distribution of fluid, lachrymal and nasal ducts — location and office;

obstruction of ducts—effect; office of tears. 18–21. The phenomena of sight—sight the result of various agencies; necessity of light; light-waves and variation in length—effects; visual sensation defined; visual judgment defined. Sensation of light lasting—illustration. Degree of intensity dependent on brightness—limitation. Phenomena explained by physics—some little understood. 22–26. Visual sensation—reception and passage of light through the eye; convergence and focus; inverted image; impression on optic nerve; recognition by brain—visual judgment. Contraction of pupil, change of shape of lens—acts of accommodation; causes of contraction of pupil. Sensitiveness of retina—variation in parts; “yellow spot” and its phenomena; axis of vision. “Blind spot”—location, phenomena, experiment. Exhausted retina—cause and phenomena. 27–29 Normal sight—nearness of object in vision—when indistinct and to what due; range in reading or writing; adjustment for distant vision. Near-sightedness—nearness of object required; causes of near-sightedness—convexity, elongation, focusing. Relief by “glasses.” Far-sight—peculiarities; inherited and from age; changes of form of eyeball and lens in far-sight—effect on focal distance; convex glasses for relief; near and far sight in same person—glasses. 30–34. Recognition of color—charm of color. Sunlight white; spectrum colors—blending and shades. Color of objects due to what—effect on retina. Color-blindness—peculiarities, probable cause; unfortunate but dangerous—reason. 35–39. Visual judgments—definition; an infant’s impressions—visual perception not judgment. Process of gaining visual judgment—association of senses, experience, etc. Agency of touch and repetition—result. Vision with both eyes—resultant image on retinas differ; combination of images—solidity impressed; stereoscope—analogy. Relation of retinal impression to brain recognition—mystery. 40. Optical delusions—origin from complex combinations and sensations, etc.; not necessarily nervous derangement—comment.

CHAP. XXXIII. — I. Essentials of perfect sight—perfect condition and correct position of parts; conditions, etc., requisite in cornea, humors—iris, pupil, lens, retina, pigment of choroid, optic nerve. 2–15. Care of the eyes—over-taxing under bad conditions; inheritance *versus* carelessness; common abuses of the eyes mentioned. Position of body in relation to light; employment of shades; position of school desks—importance. Manner of holding and position of book in reading—reason; inclining the head—congestion. Deficient and irregular light—effect. Fine work and resting of eye—method and when. Cleanliness of hands and why; towels and sore eyes—caution. Cinders, dust, etc., in eye—rubbing avoided, agency of tears in removal; methods of removing foreign body from eye. A particle

imbedded in eyeball — treatment. Lime in the eye — treatment. Exclusion of light and light bandaging — when; delay dangerous. Reading while lying — injurious and why. Cleanliness of eye and appendages — means. When to consult oculist — reason. Care in general hygienic matters, etc. — advice of an eminent oculist. 16–18. Defects requiring glasses — dangers of neglected defect, tendency to increase; defective sight — when first experienced. Selection of glasses — when prudence demands use of, by whom and why; when to use in daylight — limitation; use of single glass — injurious; use in far-sight — caution; properties of first glasses used. Normal failure of good sight — when and variation.

CHAP. XXXIV. — 1, 2. Location of the ear — a complicated organ; location of delicate parts; an element of physiognomy — expression. Difficulty of investigation — why; divisions or regions of ear named. 3. Divisions of external ear. 4. Auricle — form, peculiarities, functions in relation to sounds; hair of auricle — function. 5–8. Auditory canal — acoustic tube; dimensions and closure. Ear-wax glands — location, number, secretion, importance of. Casting out of surplus wax — conformation of canal and process of expulsion of wax and dirt. 9, 10. Tympanic membrane — location, form, size, layers, attachment. Functions described — action of air-waves communicated to auditory bones. 11. Middle ear — location, form, occupants of; divisions and adjuncts. 12–14. Tympanum or drum — size of cavity; lining and delicacy; the drum proper; most liable to disease. 13, 14. The ossicles or auditory bones — number, form, sizes, names, connection in chain, attachment to drum-head and to membrane in inner ear, vibration communicated by — process and impression. 15–18. Eustachian tube — an air-tube, location, length, openings; opened by swallowing, and air enters — result and analogy; result of closure of tube — effect on drum-head; compressed by yawning — effect. Blows on ear or explosions — effect in tube and good result; gunners and opening of mouth in firing — why. 19, 20. Mastoid cells — location and structure; air-chambers — connections; functions. Thinness of boundary wall — liability to participate in disease of drum cavity.

CHAP. XXXV. — 1 The internal ear or labyrinth — complicated nature, functions in part uncertain; central cavity, spiral tubes, winding channels — filled with water; filaments of auditory nerve — distribution; general function; divisions named. 2. Vestibule — location, form; communication with drum-cavity; oval and round windows — membranes of; and connection made with. 3, 4. Cochlea — form; spiral passages. Distribution of nerve in — harp-like; probable functions — musical sounds. 5, 6. Semi-circular canals — number, form, enlargement; effect of injury of in animals; disease of in man

— indication and conclusion as to function; afford additional surface for nerve. 7-10. Nature of sound — sound defined — analogy to wave-circles. Soundless vibration — too slow, too rapid; number of soundless per second. Sound affected by temperature, by wind, by vacuum, by rarefied air; liquids and solids as conductors — speed. Loudness, pitch, quality — dependence. 11. How we hear — mechanical action stated; perception of movement.

CHAP. XXXVI. — 1-5. Care of auricle — careful washing, drying — reason; drying in a draught — error; kind of soap. Suffering from cold ears — protection; cotton worn in ear — effect. Frost-bitten ear — care and treatment. Blows — possible effect. Piercing — disease communicated. 6-11. Care of auditory canal — improper means of removing obstruction — wax, etc. Use of sweet-oil, etc. — effect and why. Syringing as a means of cleansing — method and conditions. Insect in ear removed — method. Hard foreign body in ear-tube — method of removal and exception. Probing as means of removal — objectionable. 12-16. Care of drum-head — in swimming or diving; in sea- or surf-bathing; danger from boxing the ear and from explosions — explanations; treatment in case of ruptured membrane; deaf-dumbness from blow on head of child. Shouting in ear — why improper. Noise of boiler-making, etc. — effect and protection. 17-19. Care of Eustachian tube — unobstructed for perfect hearing — effect of cold. Mouth-breathing injurious — why. Catarrh snuffs and liquids — injury by. 20, 21. Alcohol, tobacco, and hearing — inflame throat, Eustachian tube, and hence, ear; congest blood-vessels in ear; injury to auditory nerve. Use of tobacco — catarrh of throat and nose, injury extending to ear; smoke inflames tube; cigarette — why specially harmful; atmosphere of a smoke-filled room — reason.

CHAP. XXXVII. — 1-3. Taste and smell compared — flavors and odors simultaneous; nature of mixed sensation; smell the complement of taste. Functions of taste and smell; location of the organs suggestive. Deception by these senses — reason and judgment correctors. Brutes — keenness of special senses and why. 4-6. Organ of taste — beliefs regarding seat of taste in the tongue, etc., and parts concerned; tongue the principal organ of taste — other functions; structure of tongue — papillæ, vessels, nerves; arrangement of papillæ. Process of taste — contact, moisture, solution; dry substances and taste; office of the saliva, loss of taste in fever — why. 7-9. Curiosities of taste — two sources of nerve-fibres — distribution of, in tongue, and belief concerning function; sweet and salt tastes — perceived where; sugar and back of tongue; bitter flavors — where; acids. Complex sensations of taste and smell — odor suggests taste; taste feeble when smell is obstructed — instances; sensation recognized by brain. 10, 11. Sense of smell — contributory

to pleasure and protective; entering air examined and verdict rendered. Keen smell in lower animals—guide, protection. 12-15. Organ of smell—seat of sensation—nasal cavities; olfactory nerves of mucous membrane—distribution of filaments through cribriform plate described; separation of air-passages—septum; mucuous glands and function; extent of cavity and olfactory surface; process of smelling—odorous particles, contact, moisture, result; theory of different sensation of odor. Sniffing to perceive exact odor—philosophy of. 15-21. Curiosities of smell—cultivation and education of the sense—result. Streams of odorous particles emitted—instance. Production and transmission—modifying agents; odorous plants—morning, evening, dew, rain, cold. Fainting from odors—nervous disturbance; singularity in liking for odors—fish-oil, etc., enjoyed; familiarity with repulsive odor—result. Taste and smell confused; difficulty in discriminating too closely following odors or tastes.

CHAP. XXXVIII. — 1, 2. Touch as a sensation—relation to feeling and pain—discrimination. Touch defined. Immunity from danger afforded; delicacy of the sense. 3, 4. Organ of touch—nerves in skin; papillæ; tactile corpuscles, where numerous; no direct contact with nerve—skin covering; sensitiveness to touch—dependent on what. Touch mingled with sense of pain, temperature, etc.—possible explanation of nerve-action. 5-12. Curiosities of touch—peculiarities due to what. Experiments with pointed legs of compass—single or double impression of contact in various regions of skin; deduction as to sensitiveness. Contact of crossed fingers with a small sphere—impression and possibility of distinguishing. Contact and successive impression of heat and cold without change of temperature—instances and philosophy. Different bodies of same temperature—one feeling colder than other and why. Very high and very low temperature—similarity of sensation of contact, and instance. The hand as an instrument of touch—inured to heat; membranes of mouth, tongue, etc., and hot food. Touch not a reliable thermometer; correction of impressions by; co-ordination of sensation. 13, 14. Delicacy of touch—results of cultivation; in the blind; in various occupations. Disease as related to sense of touch—intensify, modify, destroy.

EMERGENCIES.

CHAPTER XXXIX.

EMERGENCIES, OR FIRST AID TO THE INJURED.

1. **Poisoning.** — As a rule, cases of poisoning in which home treatment can be employed with advantage are those in which the kind of poison taken is known. All cases of poisoning are serious, and immediate treatment may save life; but a physician should also be summoned at once.

2. In all cases of poisoning *an emetic* should be administered as soon as possible, *except* where the poison itself produces vomiting. A table-spoonful of mustard or salt in a cupful of hot water will often serve the purpose. Tickling the throat with a feather will further assist.

3. Chemical antidotes to the action of poisons require the exercise of memory and of knowledge. *Acid poisons* are antidoted by *alkalies*, and the most convenient forms of the latter are *chalk*, *lime*, and *magnesia*. On the other hand, *caustic alkalies* are neutralized by *acids*, and hence vinegar, lemon-juice, etc., will be found most convenient in an emergency.

4. **Arsenic** is a common form of poison, and is a principal constituent of rat and insect powders, or mixtures for killing vermin. It produces faintness, nausea, vomit-

ing, and depression within an hour after it is swallowed. Intense thirst, burning pains in the stomach, violent cramps of the abdomen and legs, and cold, clammy skin also indicate arsenical poisoning. — Milk, raw eggs, and olive-oil should be administered, and friction and hot applications should be applied to the extremities. Hot fomentations should be applied to the abdomen after the severe symptoms subside.

5. **Strychnia** causes sudden and great difficulty in breathing, in from fifteen minutes to an hour after a poisonous dose has been taken. Twitching of the head and limbs is followed by violent convulsions. — *An emetic* should be given and a mixture of *camphor and water* should be administered.

6. **Opium** poisoning is indicated by contraction of the pupils of the eyes, dizziness, drowsiness, stupor, and insensibility. The person may be aroused, but quickly relapses into stupor. The skin is cold and pale, and not infrequently covered with perspiration. — *An emetic* should be given, and the person *must be kept awake* by compelling him to walk about the room or in the open air, and by means of vigorous treatment such as pinching, slapping, etc., if necessary. *Ammonia* should be held to the nostrils. *Strong coffee or tea* should be administered freely. The *same treatment* should accompany poisoning by *Morphine, Laudanum, Paregoric, "Soothing Syrup,"* and "*cordials.*"

7. **Hydrate of Chloral**, in overdoses, always produces stupor. — *An emetic* should be administered, and the person should be *kept awake* as in the case of opium poisoning. *Heat and friction* should be applied to the extremities. It may become necessary to produce artificial

respiration in the same manner as in cases of suffocation from drowning, etc.

8. Oxalic Acid produces a hot acid taste, and burning pain in the stomach. *Vomiting* occurs, and a feeling of choking or suffocation is present when this poison has been swallowed. — *Lime-water*, or chalk, lime, or magnesia in water or milk, should be administered freely. If lime cannot be otherwise obtained immediately, scrape the ceiling and thus obtain a sufficient quantity of it.

9. Carbolic Acid poisoning should be treated by administering half a cupful of *olive-oil*, or of *olive* and *castor-oil* combined with *chalk*, *lime*, or *magnesia*. *Raw eggs* may also be given, *after* all of which an *emetic* should be employed to clear the stomach. Warmth should be applied to the extremities.

10. Phosphorous poisoning should be treated with chalk, magnesia, lime, or lime-water.

11. Poisonous Mushrooms when eaten produce symptoms of intoxication, dizziness, and cause objects to appear blue to the sight. — An *emetic*, followed by a dose of *castor oil*, should be employed, and heat applied to the abdomen and extremities.

12. Coal Gas and illuminating gas, when inhaled in sufficient quantity, produce suffocation. — *Doors and windows should be thrown open* immediately. *Artificial respiration* should be kept up, *ammonia* applied to the nostrils, and *mustard poultices* to the feet. *Warm water* and *cold water* alternately dashed on the head and chest serve a good purpose.

13. Drowning. — All clothing should be quickly removed from the chest, and the person should then be turned face downward, with his forearm under his head in order to

free the mouth and nostrils from water, etc. The body should then be laid on its back with the shoulders raised on a firm cushion of clothing, etc. The tongue should be pulled forward and held by a cloth or band passed over it and under the chin. Artificial respiration may then be produced in the following manner: Grasp the arms of the person above the elbows and draw them horizontally back and above his head, keeping them in this position for two seconds; after which turn them down and press them firmly against the sides for the same length of time. Repeat these movements fifteen to eighteen times per minute, and continue them two or three hours if necessary, for persons have been resuscitated only after long-continued efforts. If an assistant is present, he should press the lower ribs together, simultaneously with the pressing of the person's arms to his sides. The first act (raising the arms) induces inspiration, the latter, expiration. *Ammonia* or other smelling-salts may be applied to the nostrils. As aids to these processes, the limbs should be rubbed *upwards* with hot cloths. Hot and cold water may be dashed alternately on the chest. When breathing is restored, the person should be placed in a warm bed in a well-ventilated room. Artificial respiration may also be produced by rolling the body alternately from the back to the side, or by raising and depressing the chest, in either instance fifteen to eighteen times per minute.

14. Sunstroke, or Heat Exhaustion. — Remove the person to a cool place in the fresh air. Pour cold water upon the head, or apply ice to it. Sponge the chest and body with cold water. Apply *ammonia* to the nostrils.

15. Bleeding from Wounds. — In bleeding from an artery, the blood escapes in jets from the wound, corresponding to

the impulses of the heart. Pressure must therefore be made *between the wound and the heart*. The pressure must be made firmly with fingers and thumbs. Such compression may then be supplemented by using a handkerchief or other bandage, placing a pad of some kind — a cork, a block, or even a stone — upon the artery between the heart and the wound, tying the handkerchief firmly over the pad, and lastly inserting a stick beneath the handkerchief and twisting it so as to press the pad tightly against the limb or other part, and thus control the bleeding.

For *internal bleeding* from the stomach or lungs, the person should take a quiet, lying posture, and should be given iced drinks, or ice to eat. *Bleeding from the nose* may be stopped by cold applied to the forehead, or to the spine, or by syringing the nose with cold alum water.

16. Burns and Scalds. — Burns and scalds may be treated by placing the burnt part in warm water containing carbonate of soda (baking soda). The clothes should be carefully removed. The burned parts should be enveloped in cloths saturated with equal parts of olive-oil, linseed-oil, and lime-water.

17. Foreign Body in the Throat. — In some instances a foreign body lodged in the throat cannot be expelled by coughing; and when so lodged as to entirely prevent breathing, active measures for its removal must be employed, in order to save life. Pending the arrival of a physician, cause the person, if an adult, to lie face downward across a chair (the body and head slanting downward as much as possible), and *strike the back smartly and repeatedly* — in the case of children, while they are being held by the legs, head downward. Attempts may be made to *reach the lodged mass with the fore-finger*, hooking it around the

obstruction if possible. In ordinary cases, efforts may be made to excite vomiting, and consequent expulsion of the intruder, by tickling the interior of the throat (*fauces*) with a feather, or other available instrument.

18. Fainting. — In fainting the circulation of the blood is temporarily arrested, or much diminished in force and volume, the breathing and functions of the nervous system being likewise suspended. Fainting may end in death, if too prolonged, or if associated with disease of internal organs, especially of the heart. Ordinarily, a person who faints from emotion, a close atmosphere, or other passing cause, may be readily restored by being laid on the back with the head low, selecting a cool place supplied abundantly with fresh air. All tight articles of clothing should be loosened or removed, and a current of cold air, or a little cold water, should be directed to the face and chest, in order to stimulate respiratory movement. Ammonia or aromatic vinegar may be applied to the nostrils for the same purpose. Compression of the ribs, and then allowing them to expand alternately, as in restoring in suffocation from drowning, is effective. "Care should be taken to ascertain that there is no obstruction in the throat or air-passages, as suffocation from mechanical causes has been mistaken for fainting, and the real origin of the mischief overlooked, with fatal consequences."

19. Disinfection. — Disinfection is the destruction of the poisons of infectious and contagious diseases.

Deodorizers, or substances which destroy smells, are not necessarily disinfectants, and disinfectants do not necessarily have an odor.

It is extremely important that the people should be instructed with regard to disinfection. They must be taught

that no reliance can be placed on disinfectants simply because they smell of chlorine or carbolic acid, or possess the color of permanganate; and that, in general, proprietary disinfectants with high-sounding names are practically worthless, as they either have no value whatever, or, if of value, cost many times as much as they are worth, and cannot be used in sufficient quantity.

Disinfection cannot compensate for want of cleanliness or of ventilation.

I. Disinfectants to be employed. — *a.* Roll-sulphur (brimstone); for fumigation.

b. Sulphate of iron (copperas) dissolved in water in the proportion of a pound and a half to the gallon; for soil, sewers, etc.

c. Sulphate of zinc and common salt, dissolved together in water in the proportions of four ounces sulphate and two ounces salt to the gallon; for clothing, bed-linen, etc.

NOTE. — Carbolic acid is not included in the above list, for the following reasons, — it is very difficult to determine the quality of the commercial article, and the purchaser can never be certain of securing it of proper strength; it is expensive when of good quality, and experience has shown that it must be employed in comparatively large quantities to be of any use; it is liable by its strong odor to give a false sense of security.

II. How to use Disinfectants. — *a.* In the Sick-Room the most available agents are fresh air and cleanliness. The clothing, towels, bed-linen, etc., should at once, on removal from the patient, be placed in a pail or tub of the zinc solution, boiling hot if possible, before removal from the room.

All discharges should either be received in vessels containing copperas solution, or, when this is impracticable, should be immediately covered with copperas solution.

All vessels used about the patient should be cleansed with the same solution.

Unnecessary furniture, — especially that which is stuffed, — carpets, and hangings, when possible, should be removed from the room at the outset ; otherwise, they should remain for subsequent fumigation and treatment.

b. Fumigation with sulphur is the only practicable method for disinfecting the house. For this purpose the rooms to be disinfected must be vacated. Heavy clothing, blankets, bedding, and other articles which cannot be treated with zinc solution, should be opened, and exposed during fumigation, as directed below. Close the rooms as tightly as possible ; place the sulphur in iron pans supported upon bricks ; set it on fire by hot coals, or with the aid of a spoonful of alcohol, and allow the room to remain closed for twenty-four hours. For a room about ten feet square, at least two pounds of sulphur should be used ; for larger rooms, proportionally increased quantities.

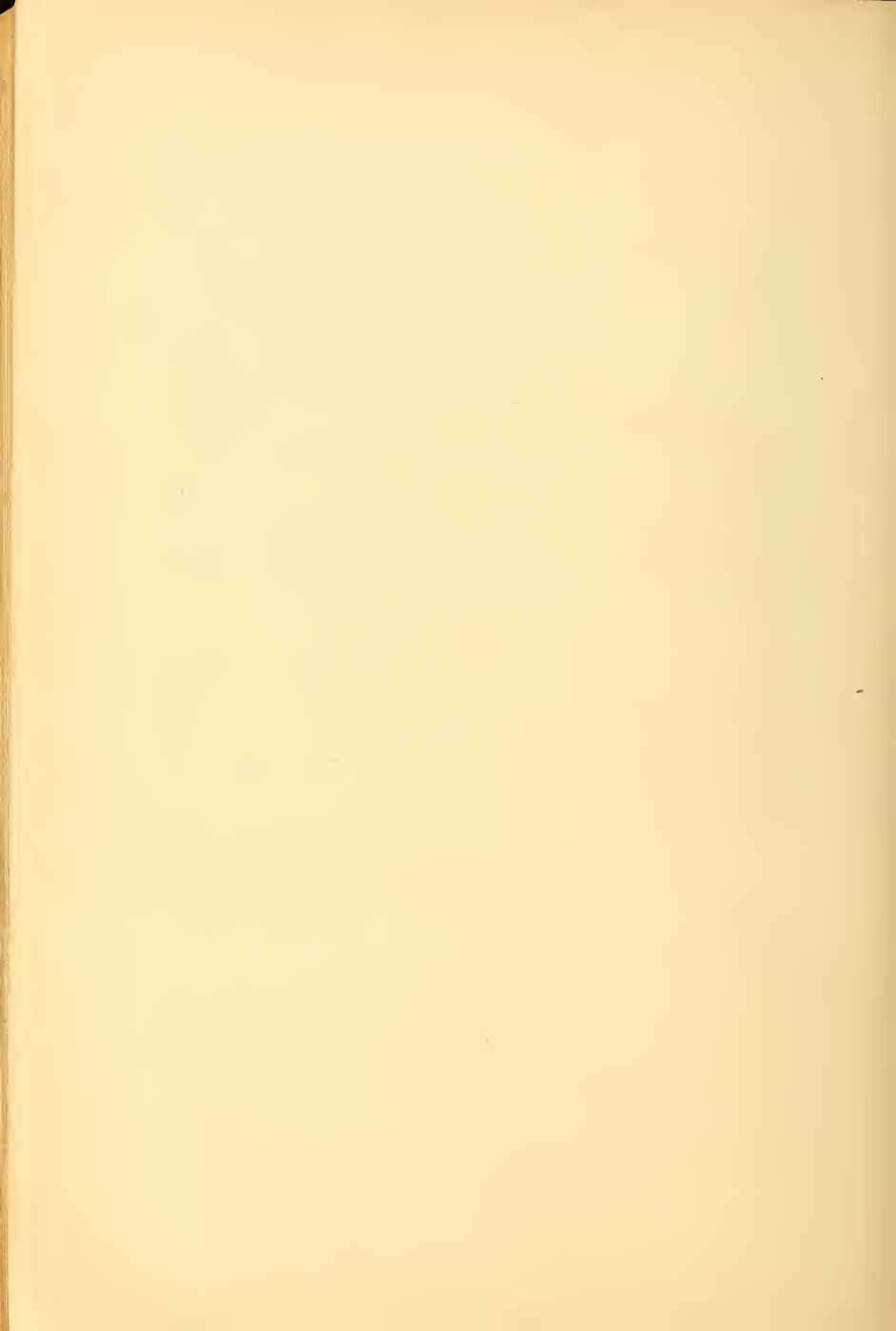
c. Premises. — Cellars, yards, stables, gutters, privies, cesspools, water-closets, drains, sewers, etc., should be frequently and liberally treated with copperas solution. The copperas solution is easily prepared by hanging a basket containing about sixty pounds of copperas in a barrel of water.

d. Body and Bed Clothing, etc. — It is *best* to burn all articles which have been in contact with persons sick with contagious or infectious diseases. Articles too valuable to be destroyed should be treated as follows : —

Cotton, linens, flannels, blankets, etc., should be treated with the boiling-hot zinc solution, introducing piece by piece, securing thorough wetting, and boiling for at least half an hour.

Heavy woollen clothing, silks, furs, stuffed bed-covers, beds, and other articles which cannot be treated with the zinc solution, should be hung in the room during fumigation, pockets being turned inside out, and the whole garment thoroughly exposed. Afterward they should be hung in the open air, beaten, and shaken. Pillows, beds, stuffed mattresses, upholstered furniture, etc., should be cut open, the contents spread out and thoroughly fumigated. Carpets are best fumigated on the floor, but should afterward be removed to the open air, and thoroughly beaten.

The dead should be thoroughly washed with a zinc solution of double strength, wrapped in a sheet wet with the zinc solution, and buried at once.



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